Evaluation of Percutaneous Pinning of Fractures of the Surgical Neck of the Humerus in Children and Adolescents Mohammed Abdulmajed Adgyeas, Adel Mohammad Salama, Mohamed Hamed Fahmy, Sameh Mohamed Holyl

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ABSTRACT

Background: Open or closed reduction with Kirschner wires, screws, and flexible nails has been documented for the treatment of displaced proximal humeral fractures, however percutaneous K-wire fixation is the most widely utilized procedure.

Objective: This study aimed to evaluate short-term clinical and radiographic results of percutaneous pinning of surgical neck-humerus fractures in children and adolescents using k-wire.

Patients and Methods: Our study was done on 18 patients with fractures of the surgical neck of the humerus at Zagazig University Hospital treated by percutaneous pinning using k-wire. The humerus fractures were followed up clinically and radiologically for 6 months. Neer and Horwitz classification was used to classify fractures. Constant-Murley shoulder scoring system were used to evaluate results.

Results: According to Constant-Murley scoring system the result obtained were excellent in 14 patient (77.78%) and good only in 4 cases (22.22%). Concerning the complications of the current study, 11 cases had no complication (61.11%), 3 cases had stiffness (16.67%) and 4 cases had superficial infection (22.22%). 4 cases of superficial infection were treated with antibiotics and daily dressing. K-wires were not required to be removed early. All of them achieved excellent results. 3 cases of stiffness were completed by physiotherapy, 2 of which yielded good results and 1 of which yielded excellent results.

Conclusion: Fractures of the surgical neck in children and adolescents can be successfully treated with percutaneous k-wires technique, which provides stability after reduction of fractures. Early and adequate physiotherapy program gives better results regarding the range of motion.

Keywords: Percutaneous pinning, Surgical neck of the humerus.

INTRODUCTION

There is a low incidence of pediatric proximal humerus fractures. Only approximately 3 percent to 7 percent of all bone fractures are physeal, and this form of fracture is more common in boys than in girls 1:3, peaking at age ten to fourteen ⁽¹⁾. Children with fractures of the proximal humerus have a great deal of remodeling potential due to the fact that about 80% of the growth in arm's length occurs at the physis of the proximal humerus ⁽²⁾. Children under the age of 11 have a better remodeling potential than older children, so non-surgical treatment is likely to produce outstanding results depending on the patient's age ⁽³⁾.

Rotator-cuff muscles are responsible for proximal segment displacement in abduction and external rotation, while pectoralis major/deltoid muscles are responsible for distal segment displacement in adduction, forward movement, and shortening ⁽⁴⁾.

Salter–Harris⁽⁵⁾ and Neer–Horowitz⁽⁶⁾ classifications are commonly used to classify proximal humerus fractures based on the extent of physeal injury and displacement, respectively⁽⁷⁾.

In general proximal humerus fractures in children are often treated with conservative methods, regardless of the severity of the angulation, displacement, translation or rotation of the fractures, despite the fact that severely displaced fractures are associated with malunion and shortening especially in older children ⁽⁸⁾.

In children above the age of 11 and adolescents with substantial displacement or angulated fractures, several

research and reports advocate surgical intervention, as the likelihood of remodeling is lowered ⁽⁹⁾.

Open or closed reduction Percutaneous K-wires fixation is the most often used procedure for treating displaced proximal humeral fractures, however screws, and flexible nails has been reported as an alternative ⁽¹⁰⁾.

It was the goal of this work to assess the union rate, deformity, shoulder range of motion, return to previous daily activities, and infections and other complications associated with percutaneous pinning of surgical neckhumerus in children and adolescents using k-wires.

PATIENTS AND METHODS

This study was conducted in the period between July 2021 and January 2022 in Orthopedic Surgery Department, Zagazig University Hospitals.

Ethical approval:

Zagazig University's Research Ethics Council approved the study as long as all participants signed informed consent forms and submitted them to ZU-IRB#7045. We adhered to the Helsinki Declaration, which is the ethical norm for human testing established by the World Medical Association.

Inclusion criteria: Age to be above 8 and below 16 years, growth cartilage visible on standard radiographs and displaced fractures of the surgical neck-humerus. **Exclusion criteria:** Dislocated or pathological fractures, neglected cases, associated neurovascular

injuries, failed previous fixation, and presence of infection.

All patients were subjected to:

Full history: Name, age, sex, residence, medical history of chronic and metabolic diseases, date of examination and/or admission, contact information and other habits of medical interest.

Clinical examination: General examination, local examination and neurovascular examination were done.

Laboratory investigations: Complete blood picture, random blood sugar, and renal function tests.

Radiological investigations:

Plain x-ray: Antero-posterior view of the affected shoulder.

Immobilization: The affected limb was immobilized in sling and swathe. All patients were treated by percutaneous pinning under an image intensifier using Kirschner-wires.

Operative technique: Anesthesia:

An hour before the procedure, a broad-spectrum intravenous antibiotic was administered. All patients were operated under general anesthesia with muscle relaxants.

Positioning:

After anesthetic has been administered, the patient can be placed in the supine position. Positioning patients lateral to the table with lateral chest support ensured that they wouldn't be pulled out during surgery. A head holder held the patient head in place. The entire limb was draped from the base of the neck to the midline of the chest. The image intensifier was placed in the right place to visualize the proximal humerus and glenohumeral joint in two orthogonal planes.

Reduction: The distal fragment was abducted and externally rotated in order for it to line up with the abducted and externally rotated proximal fragment in an effort at a closed reduction. To assess the reduction, an image intensifier was used. The deltopectoral method can be used if close reduction is not possible.



Figure (1): Reduction maneuver (longitudinal traction then abduction and external rotation).

K-wire placement:

Percutaneous smooth K-wires are used to stabilize the fracture after a sufficient closure reduction has been accomplished. Two K-wires were inserted into the humerus, either through the lateral portion of the shaft or the humeral head. To ensure proper alignment and implant placement, multiplanar fluoroscopic images are taken. The third and fourth wires can be added either antegrade or retrograde in case of unstable fixation. The axillary nerve is in danger as it travels from the posterior to the anterior across the proximal humerus in a 5-7 cm distal to the acromion tip area. The safe starting point for the pins is distal to this.

while entering each k-wire through the cortex, drilling a small pilot hole perpendicular to the humerus to prevent the wire from slipping on the cortex, then reinserting the wire across the fracture site.



Figure (2): Insertion of first K-wire (retrograde or antegrade).



Figure (3): Additional wires to increase stability.

Follow up: Patients were followed every week in first month and every 2-3 weeks for 3 months. Elbow and wrist range of motion exercises can be started immediate according to pain tolerance.

Radiological evaluation:

Antero-posterior and lateral radiographs should be performed every two weeks to monitor bone healing and union until the pins are removed after four or six weeks, and then every three months after that.

Clinical evaluation:

Constant-Murley ⁽¹¹⁾ Functional Shoulder Assessment score was used to evaluate functional outcomes at the end of this period.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM SPSS Inc., Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages.

Chi square test (χ^2) to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean \pm SD (Standard deviation). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value ≤ 0.05 was considered significant.

RESULTS

The age of the patients in this work ranged from 8 - 15 with the mean of 12.22 ± 2.04 years. There were 13 males (72.22%) and 5 females (27.78%) with male to female ratio 1: 2.6. Right side was affected in 11 cases (61.11%), while the left was affected in seven patients (38.88%) (**Table 1**).

Table	(1):	Age	and	sex	distribution	among	studied
group	(N=1)	8)					

Age	Mean ± SD	1	2.22 ± 2.04	
(years)	Median (Range)	12.5 (8-16)		
Sex		Ν	%	
	Female	5	27.78	
	Male	13	72.22	
	Total	18	100.0	

The main mechanism of injury was fall from height (FFH) in 12cases (66.67%), road traffic accident (RTA) in 3 cases (16.67%), Direct trauma in 2 cases (11.1%) and 5.56% were caused by sport injury in 1case. According to NEER classification 13 patient had grade 4 (72.22%), 4 cases had grade 3 (22.22%) and 1 case had grade 2 (5.56%). There were 2 case (11.11%) associated with other injuries (1case with pneumothorax same side of fracture and the other associated with ipsilateral fracture shaft of femur and both bones of the leg), and 16 cases (88.89%) without associated injuries (Table 2).

Table (2): Trauma characters dist	ribution among
studied group	

		Ν	%
Sido	Left	7	38.89
Side	Right	11	61.11
	Total	18	100.0
	Direct trauma	2	11.11
Type of	FFH	12	66.67
trauma	R.T.A	3	16.67
	Sport injury	1	5.56
	Total	18	100.0
Neer	Grade 2	1	5.56
Neer	Grade 3	4	22.22
classification	Grade 4	13	72.22
	Total	18	100.0
Associated	No	16	88.89
injuries	Poly trauma	2	11.11
	Total	18	100.0

The union time mean was 5 ± 0.685 weeks with minimum of 4 weeks and maximum 6 weeks. Majority of studied group 10 cases had union at 5 weeks (55.6%), 5 cases had union in 6 weeks (22.22%), and 3 cases had union in 4 weeks (22.22%) (**Table 3**).

 Table (3): Duration of union distribution among studied group

Mean± SD		5 ± 0.685		
Median (Range	e)	5.0 (4-6)		
		Ν	%	
Duration of	4	4	22.22	
union	week			
	5	10	55.56	
	week			
	6	4	22.22	
	week			
Total		18	100.0	

Analysis of Constant- Murley score (Table 4):

1. Pain: The pain score 15 points at end of the follow up period 14 patient had no pain (77.8%) and 4 patient had mild pain (22.2%).

2. Activity of daily living: (a) The ability of the patients to do daily work, engage in recreational activity and sleep with total score of 10 points,14 patients had the ability to fulfill all the activities (77.8%) and 4 patients showed some restricted activities (22.2%), while none of the patients had disturbed sleep pattern. (b) The ability for positioning the arm at specific level in painless manner with total score of 10 points. 13 patients had the ability for positioning the arm overhead (72.22%) and 5 patients had the ability to position the arm at the same level of the head (27.78%).

3. Range of motion:

a-Forward flexion and abduction: In our assessment we measured movements of the shoulder joint in degrees, using a goniometer. The average normal forward flexion in this series (as measured on the intact shoulder joint of each patient) was 170° (ranged from 150° to 180°). While the average normal abduction (as measured on the intact shoulder joint of each patient) was 175° (ranged from 150° to 180°). 13 patients had active flexion above 150° (72.22%) and 5 patients had active flexion from 121° to 150° (72.22%) and 5 patients had active abduction from 121° to 150° (27.78%). The mean final score of active abduction was 9.4 ± 0.92 points out of 10 points.

b-External rotation: 13 patients could do full active external rotation (72.22%) and 5 patients could not do full elevation (27.78%). The mean final score of external rotation was 9.4 ± 0.92 points out of 10 points. **c-Internal rotation:** Nine patients could do active internal rotation to interscapular region (50%), eight patients could do actively to 12 dorsal vertebra (44.4%) and 1 patient could do actively to the waist (5.6%).

4. Power: It was examined by comparing muscle resistance of both shoulders at 90° of abduction. There were 14 patients with full muscle strength (77.8%) and 4 patients with mild muscle weakness (22.2%).

Table (4): Constant- Murley score items and total score distribution among studied group

		Ν	%
Pain	None	14	77.8
	Mild	4	22.2
Work and	Affected	4	22.2
recreational	Full work	14	77.8
Arm	Above head	13	72.22
Positioning	Up to head	5	27.78
Power	Full	14	77.8
	Mild weakness	4	22.2
Range of	121—150	5	27.78
motion	151-180	13	72.22
foreword			
flexion			
Range of	121-150	5	27.78
motion	151-180	13	72.22
abduction			
Range of	Full elevation	13	72.22
motion	Not full elevation	5	27.78
external			
rotation			
Range of	Thumb point to	9	50
motion	interscapular		
internal	region		
rotation	Thumb point to	8	44.44
	12 dorsal vertebra		
	Thumb point to	1	5.56
	waist		
Total	Excellent	14	77.78
Constant	Good	4	22.22
score Total		18	100.0

Total Constant score: 14 cases were excellent score with (77.78%) and 4 cases only good score (22.22%) **(Figure 4).**



Figure (4): Total Constant–Murley Score.

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In this study, 11 cases had no complication (61.11%), 3 cases had stiffness (16.67%) and 4 cases had superficial infection (22.22%). 4 cases of superficial infection were treated with antibiotics and daily dressing. K-wires were not required to be removed early. All of them achieved excellent results. 3 cases of stiffness were completed by physiotherapy, 2 of which yielded good results and 1 of which yielded excellent results. Statistically, there was no significance between (demographic and clinical data) with complications (**Table 5**).

Table (5): Complication distribution among studied group and relation between demographic and clinical data and complication

				Ν	9/	Ó
Complication None Stiffne		ne		11	66.66	
		ffness		3	16.67	
Super		erficial infect	tion	4	16.67	
	Tot	al		18	100.0	
			Complicated	Non	t/ X ²	Р
Age			11.85±2.54	12.41±1.75	-0.25	0.58
Duration of union			5±0.81	5±0.63	-0.54	0.65
Sex	Female	Ν	1	4		
		%	5.56%	22.22%	1.02	0.20
	Male	Ν	6	7	1.05	0.50
		%	33.33%	38.89%		
Side	Left	Ν	4	3		
		%	22.22%	16.67%	1.50	0.20
	Right	Ν	3	8	1.59	0.20
		%	16.67%	44.44%		
Type trauma	Direct	Ν	1	1		0.60
	trauma	%	5.56%	5.56%		
	FFH	Ν	4	8	1.86	
		%	22.22%	33.3%		
	R.T.A	Ν	2	1		
		%	11.11%	5.56%		
	Sport	Ν	0	1		
	injury	%	0	5.56%		
Neer	Grade 2	Ν	0	1		
classification		%	0	5.56%		
	Grade 3	Ν	2	2	0.84	0.65
		%	11.11%	11.11%		
	Grade 4	Ν	5	8		
		%	27.78%	44.44%		
Associated	No	Ν	6	10		
injuries		%	33.33	55.56	70 /	0.10
	Yes	Ν	1	1	/8.4	8.10
		%	5.56	5.56		
Pain	None	Ν	5	9	- 0.26	0.60
		%	27.78%	50%		
	Mild	Ν	2	2	0.20	0.00
		%	11.11%	11.11%		
Total Constant	Excellent	Ν	5	9		
score		%	27.78%	50.0%	0.26	0.60
	Good	Ν	2	2	0.26	0.60
		%	11.11%	11.11%]	
Total	•	Ν	7	11		
		%	38.89%	61.11%		



Figure (5): Radiological evaluation of case (1), (a) preoperative, (b) postoperative, (c) at the final follow up; fracture of the surgical neck of the right humerus, Neer and Horwitz classification Grade IV of 14 years old male, The patient was operated by CRPP under C-arm imaging using 3 lateral 1.8 mm k-wire. At 3 months, clinical evaluation was done using the Constant- Murley score. The patient had good score.

DISCUSSION

The most common causes of proximal humeral fractures are falling on an outstretched hand with the elbow extended and the shoulder externally rotated, or direct shoulder trauma. A quarter of all proximal humerus fractures in youngsters occurs as a result of sports-related injuries, while a further third is the result of car accidents. There is a 3–4 fold increase in male vulnerability compared to female vulnerability ⁽¹²⁾.

Pediatric proximal humerus fractures can be treated surgically in a number of ways that are both safe and successful. For both physeal and metaphyseal fractures, PP fixation offered acceptable stability and preservation of reduction in the immediate postoperative phase ⁽¹³⁾. In this study, patients age was 12.22 ± 2.04 ranged from 8 to 15 years, from them 13 patients were males (72.22%) and 5 were females (27.78%) with male to female ratio (1: 2.6). The same age and male percentage were detected in a study conducted by Shore et al. (14) in a total of 84 patients were included in their retrospective analysis, the age of the studied group was 13.8 ± 2.25 years and male percentage were (73%). Regarding to the affected side, right sided affection occurred in 11 patients (61.1%), while left side affection occurred in seven patients (38.89%). Similar data was collected from Bisaccia et al. (15) as 31 children having proximal humeral fractures were included in the study, 58% of them had right sided lesion, while (42%) of them had left sided lesion (69). In contrast with Ali et al. (16). Fracture of the right side was present in 11 patients (36.67%) and fracture of the left side in 19 patients (63.33%).

This study showed that fall from height (FFH) was in 12 cases (66.67%), road traffic accident was in 3 cases (16.67%), direct trauma was in 2 cases (11.1%) and 5.56% were caused by sport injury in 1 case. **Ye** *et al.* ⁽¹⁷⁾ showed that fall on the ground was the cause of injury in 58.18% of patients, while 16.3% of patients had traffic accident mechanism of injury (13).

In this study, 13 cases were grade 4 (72.22%), 4 cases were grade 3 (22.22%) that were encountered following Neer-Horwitz classification and only 1 case associated with other injury was Neer-Horowitz grade-2 (5.56%). Pavone et al. (10) reported that of the 26 fractures, ten patients (38.5 %) had a Neer-Horowitz grade-3, while 16 patients (61.5 %) were Neer-Horowitz grade-4.Concerning the union time, mean was 5 ± 0.685 weeks with minimum of 4 weeks and maximum of 6 weeks with 55.56% of the studied group need 5 weeks for union, (22.22%) need 6 weeks for union and (22.22%) need only 4 weeks. These results are in accordance with Hohloch et al. (18) who reported that the mean time till union was 3.8 weeks after percutaneous pinning and 3.69 weeks with conservative treatment of proximal humerus fractures in children. While, Chae et al.⁽¹⁾ found that the overall mean time to the radiological union from the date of injury was 21.8 days (3.1 weeks).

Concerning the complications in this study, 12 cases had no complication (66.7%), 3 cases had stiffness (16.7%) and 2 cases had superficial infection (11.1%). Two cases of superficial infection did not necessity early removal of K-wires. All of them were treated with oral antibiotics. All of them achieved excellent results. 3 cases of stiffness received physiotherapy, 2 of them achieved good result and the other achieved excellent result. Hohloch et al. (18) reported that 9% of the complications occurred in the patients treated by K-wire fixation. On the other hand, Bahrs et al. ⁽³⁾ reported that K-wires pinning in their study to be a safe treatment option for proximal humeral fractures both in patients less than 10 years and in patients of more than 10 years of age. Concerning analysis of Constant-Murley score, in our study 14 patients (77.78%) yielded excellent results and 4 patients (22.22%) yielded good results.

The pain score consisted of 15 points. At the end of the follow up period (14) patients had no pain (77.8%) and 4 patients had mild pain (22.2%). The ability of the patients to do daily work, engage in recreational activity and sleep with a total score of 10 points 14 patients had the ability to fulfill all the activities (77.8%) and 4 patients showed some restricted activity (22.2%), while none of the patients had disturbed sleep pattern. The ability to use the hand at specific level in painless manner with a total score of 10 points. 14 patients had the ability to do painless overhead work (77.8%) and four patients had the ability to work at the same level of the head (22.2%).

Regarding range of motion, the average normal forward flexion in this series (as measured on the intact shoulder joint of each patient) was 170° (ranged from 150 ° to 180 °). While the average normal abduction (as measured on the intact shoulder joint of each patient) was 175° (ranged from 150° to 180°). Twelve patients had active flexion above 150° (66.7%) and 6 patients had active flexion from 121° to 150° (33.3%). Twelve patients had active abduction from 121° to 150° (33.3%) with mean final score of active abduction was 9.20 ± 1.20 points out of 10 points.

All the studied group (18 patients) could do full active external rotation according to constant-Murley shoulder score (100%). Fourteen patients could do active internal rotation to interscapular region (77.8%), 3 patients could do actively to 12 dorsal vertebra (16.7%) and 1 patient could do actively to the waist (5.6%).

Power was examined by comparing muscle resistance of both shoulders at 90° of abduction. There were 14 patients with full muscle strength (77.8%) and 4 patients with mild muscle weakness (22.2%). Chaus et al. ⁽¹⁹⁾ retrospectively compared percutaneous pinning and nonoperative management in 14 patients with Neer-Horwitz grade III or IV fractures. There were no differences in functional outcomes, complications, or rate of return to pre-injury activity. However, less than desirable outcomes were noted in patients at least 12 years old who were managed nonoperatively. Kraus et al.⁽²⁰⁾, in a retrospective study, compared percutaneous pinning and intramedullary nailing in 31 pediatric patients also with Neer-Horwitz grade-III or IV proximal humeral fractures. Their results showed no difference in functional or radiographic outcomes; however, percutaneous pinning led to both a shorter hospital stay and shorter time to implant removal.

CONCLUSION

We concluded that fractures of the surgical neck in children and adolescents can be successfully treated with percutaneous k-wires technique, which provides stability after reduction of fractures. Early and adequate physiotherapy program gives better results regarding the range of motion.

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