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Surgical Treatment of Pediatric Proximal Humeral Fracture by Percutaneous Pinning

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ABSTRACT
Background: Proximal humeral fracture pattern varies based on the mechanism of injury and the patient's age at the time of the injury. The purpose of this study was to prove short-term clinical and radiographic results of closed reduction and percutaneous pinning in displaced proximal humeral fractures in pediatric by K-wire. **Subjects and Methods**: This was clinical trial study included 18 children with proximal humeral fracture; their age ranged from 8 to 15 years with mean age 11.88 ± 2.08 with closed proximal humeral fracture between November 2019 and June 2020 at Zagazig University Hospital by closed reduction and percutaneous pinning under image intensifier using Kirschner-wires. **Results**: This study showed that 12 cases had no complication (66.7%), 3 cases had stiffness (16.7%), 2 cases had superficial infection (11.1%) and 1 case had loss of reduction (5.6%) and treated by K-wire removal, arm sling stabilizer. Two cases of superficial infection did not necessitate early removal of K-wires. All of them were treated with oral antibiotics. **Conclusions**: Additional K-wires through the lateral cortex give more stability for the severely displaced fractures with rotational or angular instability mainly type 4 fractures.
Keywords: Closed reduction, Kirschner-wires, Proximal Humeral Fracture, Percutaneous pinning,

INTRODUCTION

Proximal humeral fracture pattern varies based on the mechanism of injury and the patient's age at the time of the injury. Pediatric proximal humeral fractures are not common. Studies estimate that these fractures constitute approximately 2% of all pediatric fractures and 3% to 6.7% of all physical fractures [(1)].

Treatment of proximal humeral fractures is rarely debatable. The traditional teaching is that non-operative treatment is expected to give satisfactory results with return to full function and complete anatomic remodeling [(2)].

Fractures of proximal humerus, including fracture of the epiphysis, and surgical neck, have huge remodeling potential because of longitudinal humeral growth, which accounts for age dependency for 80% of humeral growth [(3)].

Proximal humeral fractures are classified by their anatomic location, displacement, and angulation. Proximal humeral fractures are commonly diagnosed according to the Salter Harris classification scheme. Most of these fractures are either non displaced Salter Harris I fractures, or displaced Salter Harris II fractures. It is extremely rare to see a Salter Harris III or IV proximal humeral fracture. Neer classified pediatric proximal humeral fractures based on the amount of displacement. Grade I fracture has less than 5 mm of displacement; grade II has between 5 mm and one third the diameter of the humeral shaft; grade III has between one third and two thirds the diameter of the humeral shaft; and grade III fractures has displacement greater than two thirds the diameter of the humeral shaft [(4)] .

Varus is the usual direction of proximal humeral fracture displacement, with proximal fragment (epiphysis) displacement in abduction and externally rotated due to rotated cuff muscles and distal fragment (shaft) displacement anterior and adduction due to pectoralis major and deltoid muscles [(5)].

Regardless of the degree and severity of displacement, open treatment of proximal humeral fractures in children is rarely justified. This is in spite of the fact that the majority of patients in grade IV (displacement greater than 2/3 of the humeral shaft) group had persistent deformity and many had notable arm shortening compared to the opposite side[(6)].

Several other published studies have attempted to address the reasons for potential malunion in many of these cases. These studies have alluded to the interposition of the periosteum or the long head of the biceps tendon within the fracture site as factors that block satisfactory restoration of alignment and fracture reduction with closed techniques [(7)].

Closed reduction and percutaneous pinning of displaced proximal humeral fracture has its role if obtaining accepted satisfied reduction of proximal humeral fracture is achieved. Although closed reduction and percutaneous pinning give satisfactory result in displaced proximal humeral fracture for pediatric. Yet it has complication as pin tract infection, migration of pin and osteomyelitis [(8)]. The aim of this study was to prove short-term clinical and radiographic results of closed reduction and percutaneous pinning in displaced proximal humeral fractures in pediatric by K-wire.

SUBJECTS AND METHODS

This was clinical trial study included 18 children with proximal humeral fracture their age ranged from 8 to 15 years with mean age (11.88 ± 2.08)

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with closed proximal humeral fracture between November 2019 and June 2020 at Zagazig University Hospitals. The mechanisms of injury included fall from height (FFH) in 10 cases (55.6%), road traffic accident in 5 cases (27.8%), direct trauma in 2 cases (11.1%) and 1 case (5.5%) was caused by sport injury. Right side was affected in 10 cases (55.6%), while the left was affected in eight patients (44.4%).

Inclusion criteria: Age above 8 and below 15 years. The patient could tolerate general anesthesia. There was no or minimal skin compromise of the injured shoulder. Closed displaced fractures of the proximal humerus. Absence of associated neurovascular injuries. Growth cartilage visible on standard radiographs.

Exclusion criteria: Fracture dislocation. Associated neurovascular injuries. Neglected cases. Failed previous fixation. Hematological or rheumatological diseases. Presence of infection. Absence of growth cartilage on standard radiographs. Polytraumatized patients and compound fractures, and pathological fractures.

Ethical approval:

The study was approved by the institutional ethics committee of Zagazig University and also informed written consent was taken from patients and/or their caregivers after explaining the procedure and possible complications. **This Work was performed according to the code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.**

All patients were subjected to history taking, clinical, radiological examination and laboratory investigations. Patients were examined for any systemic diseases as diabetes mellitus. Local examination included skin condition. Neurovascular examination. Vascular examination included examination of peripheral pulsation (radial and brachial pulsations) for absent or unequal pulsation. Radiological examination. Laboratory investigations included CBC. Random blood sugar. Renal function test. U shap slab and arm pouch-sling for fracture limb was done to stabilize fracture and reduce pain.

Operative technique: Systemic broad-spectrum intravenous antibiotic was given an hour before the operation. Surgery was done under general anesthesia for all patients with muscle relaxant to facilitated reduction. The patient was positioned as far laterally on the table as possible with lateral thorax support to prevent the patient from being pulled off the operating table. The head was immobilized in a head holder. The involved extremity was draped to allow free mobility for reduction maneuvers, fixation, and radiographic imaging. Image intensification was positioned to allow complete visualization of the proximal humerus and glenohumeral joint in two orthogonal planes. K-wire was introduced form proximal to distal through the greater tuberosity in 13 cases. In 10 cases (55%) additional K-wire was inserted from distal to proximal through the lateral cortex for more stability of the reduced fracture mainly in grade 4 fractures. In 3 cases 2 K-wires were inserted from distal to proximal through the lateral aspect of humeral shaft and in 2 cases 3 K-wires were inserted from distal to proximal through the lateral aspect of humeral shaft. After the first pin was placed, multiplanar fluoroscopic views were obtained to confirm appropriate alignment and implant placement. Following this one or two additional pins were placed.

Postoperative care: All patients were immobilized in arm pouch with cuff and collar sling. Appropriate antibiotics and analgesics were used. Immediate postoperative radiographs were taken to determine the bone alignment and maintenance of reduction. Passive range of motion and pendulum exercises were begun immediately depending on pain from third week.

Follow up: All patients were followed every week in first month and every 2-3 weeks for 3 months. The active range of motion were started at 1-2 weeks postoperatively, depending on stability of osteosynthesis and bone quality. Pins were removed between 4-6 weeks according to the union. The sling were discontinued by 8-12 weeks depending upon fracture stability. Further follow up was at 8 weeks and 12 weeks. The patients were examined clinically and radiologically and were assessed for range of motion and bony union and complication. The patients with shoulder stiffness were given physiotherapy for 1 week to 15 days.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Independent-samples t-test of significance was used when comparing between two means.

Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters. The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following: P-value <0.05 was considered significant. P-value <0.001 was considered as highly significant. P-value >0.05 was considered insignificant.

RESULTS

The age of the patients in this work ranged from 8 to 15 years. Male to female ratio was 3.5:1 (Table 1).

Table (1): Age and sex distribution among studied group (N=18)

Age			
Mean± SD		11.88±2.08	
Median (Range)		12.0 (8-15)	
		N	%
Sex	Female	4	22.2
	Male	14	77.8
	Total	18	100.0

According to NEER classification 15 patient had grade 4. There were 17 cases without associated injury, and 1 case associated with lateral condyle fracture of humerus in the same side, which was treated by closed reduction and percutaneous pinning (Table 2).

Table 2: Trauma characters distribution among studied group

		N	%
Side	Left	8	44.4
	Right	10	55.6
Type trauma	Direct trauma	2	11.1
	FFH	10	55.6
	R.T.A	5	27.8
	Sport injury	1	5.55
Neer classification	Grade 2	1	5.6
	Grade 3	2	11.1
	Grade 4	15	83.3
Associated injuries	No	17	94.4
	Lateral condyle humerus	1	5.6
	Total	18	100.0

At end of the follow up period 14 patient had no pain. Table 3 showed that 12 patients had active flexion above 150º. The mean final score of active abduction was 9.20 ± 1.20 points out of 10 points. It was examined by comparing muscle resistance of both shoulders at 90º of abduction. There were 14 patients with full muscle strength. 15 cases had excellent score and 3 cases had only good score.

Table 3: Constant- Murley score items and total score distribution

		N	%
Pain	None	14	77.8
	Mild	4	22.2
Work and sleep	Affected	4	22.2
	Full work	14	77.8
Movement of hand	Above head	14	77.8
	Up to head	4	22.2
Power	Full	14	77.8
	Mild weakness	4	22.2
Range of motion	FF 121—150	6	33.3
	FF 151-180	12	66.7
Range of motion	Abd 121-150	6	33.3
	Abd 151-180	12	66.7
Range of motion3	Ex ro full	18	100.0
Range of motion4	In ro dorsum to 12 dorsal v	3	16.7
	In ro dorsum to wais	1	5.6
	In ro to intra s region	14	77.8
TOTAL Constant score	Excellent	15	83.3
	Good	3	16.7
	Total	18	100.0

This study showed that 12 cases had no complication (Table 4). 2 cases of superficial infection did not necessitate early removal of K-wires. All of them were treated with oral antibiotics. All of them achieved excellent results. In 3 cases of stiffness physiotherapy was done, 2 of them achieved good result and 1 of them achieved excellent result. 1 case of loss of reduction was treated by K- wire removal and arm sling stabilizer.

Table 4: Complication distribution among studied group

		N	%
Complication	None	12	66.7
	Loss of reduction	1	5.6
	Stiffness	3	16.7
	Superficial infection	2	11.1
	Total	18	100.0

DISCUSSION

This clinical trial included 18 children with proximal humeral fracture; their mean age was (11.88 ± 2.08) ranged from 8 to 15 years. 14 patients were males (77.8%) and 4 were females (22.2%) with male to female ratio (3.5:1), the same age was detected in a study conducted by **Shore *et al.*** [9] in a total of 84 patients were included in their retrospective analysis. The mean age of the studied group was (13.8 ± 2.25) years.Oppositely these demographic data was in contrast with the results of **Chae *et al.*** [10] whose data collection from the included patients showed that the mean age of children with PHF was 8.6 years old with 56% of these fractures occurring in females and 44% in males. The age of the cohort ranged from one month to 15 years old.

Also**, Hannonen *et al.*** [11] found in their study that the affected group was consisted of (177) girls and (123) boys with a proximal humerus fracture. Their mean age was 10.2 years at the time of fracture.

Regarding the affected sides, right side was affected in 10 cases (55.6%) While the left was affected in eight patients (44.4%), the main mechanism of injury was full from high (FFH) in 10cases (55.6%), road traffic accident in 5 cases (27.8%), direct trauma

in 2 cases (11.1%) and (5.5%) were caused by sport injury in 1 case.

According to NEER classification, fifteen patients had grade 4 (83.3%), 2 cases had grade 3 (11.1%) and 1 case had grade 2 (5.6%). These findings were in contrast with **Isik *et al.*** [12] who stated that Neer grade I and II proximal humerus fractures in children and older adolescents also should be treated non-surgically. Various methods of immobilization have been advocated, and good results have been obtained using hanging arm casts, slings, slings and swathes, and even Velpeau bandages. Additionally they said that nonsurgical care was not recommended for patients with open Neer grade I and II fractures, vascular injury, or polytrauma.

Controversy exists with regard to the management of Neer and Horwitz grade III and IV pediatric proximal humerus fractures. Finally they concluded that two factors must be considered for appropriate treatment of these fractures: (1) the chronologic and skeletal age of the patient and (2) the amount of displacement and angulation present [11].

Concerning associated injuries, there were 17 cases (94.4%) without associated injury, and 1 case (5.6%) associated with lateral condyle fracture of humerus in same side which treated by closed reduction and percutaneous pinning. This was the same as the finding of **Pandya *et al.*** [13] who reported that the most common mechanism of injury in children was a backward fall onto an outstretched arm and adolescents usually present from sporting accidents, involving a direct impact to the arm or falls during sport**.** Also this was similar to the findings of **Chae *et al.*** [10] where the most common cause of injury was falls (70%, n = 29). There were two sports-related injuries (5%), both of which were in male patients. There was one fracture from a non-accidental injury (2.4%) and one suspected pathological fracture in a patient with global developmental delay and suspected disuse osteoporosis (2.4%). It should be noted that (20.0%) of the cases did not have a recorded mechanism of injury.

All cases were treated by closed reduction and percutaneous pinning technique and short -term follow up after the operation was done to assess the outcome.

Concerning analysis of Constant-Murley Score and patients' outcome; the pain score is 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 150º (66.7%) and 6 patients had active flexion from 121º to 150º (33.3%). Twelve patients had active abduction above 150º (66.7%) and 6 patients had active abduction from 121º to 150º (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 90º of abduction. There were 14 patients with full muscle strength (77.8%) and 4 patients with mild muscle weakness (22.2%).

The results of **Shore, *et al.*** [9] study demonstrated that leaving pins exposed after surgical treatment of pediatric proximal humeral fractures is safe and confers greater cost savings than burying the pins or using intramedullary fixation. The decision analysis revealed that leaving pins exposed (PPE) after operative fixation of proximal humerus fractures was the most cost-effective strategy.

Chae *et al.* [10] said that most professionals agree that the three main factors which govern the decision to operate children with PHF are age, angulation and skeletal maturity of the patient. This has given rise to three distinct treatment groups within the pediatric population, namely patients of ages fewer than 10, older than 13 and between 10 and 13. In the first group (under 10 years of age), a non-operative approach is preferable even a severely displaced fracture of 21 mm of translation and 49 degrees of AP angulation was deemed acceptable and treated with a collar and cuff and their outcome was successful with the restoration of full limb function. Although satisfactory clinical progress took longer than the average in their cohort, the risk of undergoing unnecessary surgery was avoided. This was completely agreed with the current study.

Concerning the outcome of the current study, in this study 12 cases had no complication (66.7%), 3 cases had stiffness (16.7%), 2 cases had superficial infection (11.1%) and 1 case had loss of reduction (5.6%). Two cases of superficial infection did not necessitate early removal of K-wires. All of them were treated with oral antibiotics. All of them achieved excellent results. Physiotherapy was done for the three

cases of stiffness; two of them achieved good result and the other achieved excellent result. One case lost reduction and treated by K-wire removal and arm sling stabilizer.

This good to excellent outcome was in agreement with **Popkin *et al.*** [1] who demonstrated that in pediatric patients with proximal humeral fractures, the potential for remodeling is great; therefore, most of these fractures can be successfully treated non-surgically. Traditionally, nonsurgical management of pediatric proximal humerus fractures produced well to excellent results in all pediatric age groups.

Simultaneously in a study of 43 patients with proximal humeral fractures (10 treated non-surgically, 33 treated surgically) conducted by **Cruz *et al.*** [8] found no complications at a mean follow-up of 39 months, with excellent Constant Scores reported in those with non-displaced and displaced fracture patterns and attributed this because of the remodeling potential of the humerus in young patients with proximal humeral fractures, treatment outcomes are generally good to excellent**.**

Additionally in a systematic review of pediatric proximal humeral fractures; **Pahlavan *et al.*** [14] reported excellent overall outcomes; most patients were able to return to activity with no restrictions, no residual loss of function, and no major complications.

Finally the results of the current study were in contrast to **Hannonen *et al.*** [11]**,** where ten cases, which were primarily treated non-operatively, had to be surgically fixed later because of re-displacement. Further, one patient was re-operated after primary surgical treatment (4.2%, 1/24) due to a symptomatic scar. One in five (20%) of the boys suffered from complications and (14.7%) of the girls.

CONCLUSION:

Additional K-wires through the lateral cortex give more stability for the severely displaced fractures with rotational or angular instability; mainly type 4 fractures.

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