Outcomes of Percutaneous Pinning Technique in the Management of Two-Part and Three-Part Proximal Humerus Fracture in Adults

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Abstract

Background: Proximal humerus fractures represent 4-5% of over-all fractures. In patients above 40 years of age, it accounts for 75% of all humerus fractures. Fractures of the proximal end of the humerus oftentimes represent a management dilemma with the multiple surgical options available to deal with them.

Objective: To evaluate the functional and radiographic outcomes of the percutaneous pinning techniques in the management of two-part and three-part proximal humerus fracture.

Patients and Methods: A case series of 25 patients, functional outcome was determined by ASES and Constant scores and multiple radiographic views were taken to assess the fracture union, mal-union, and the presence of avascular necrosis.

Results: ASES score of the whole group was 87.27 while the mean Constant score was 79.04. Only 16% of the entire group developed varus malunion (defined by Neck-Shaft-Angle <=120degrees). Moreover, 16% of the whole group developed OA of the glenohumeral joint.

Conclusion: This study supports that the percutaneous close reduction and pinning technique is an effective and reliable surgical technique in the management of closed two-part and three-part proximal humerus fractures in adults. Appropriate preoperative planning is important to achieve a successful surgical result, and regular postoperative follow-up and rehabilitation are essential to get an optimum functional outcome.

Keywords: Proximal humerus fracture, percutaneous pinning, upper extremity surgery, trauma surgery, Clinical outcomes, Percutaneous fracture fixation

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Introduction

Proximal humerus fractures, defined as fractures occurring at or proximal to the surgical neck of the humerus, represent 4-5% of over-all fractures [1]. In patients above 40 years of age, it accounts for three quarters of all humerus fractures [2]. Fractures of the proximal end of the humerus oftentimes represent a management dilemma. Understanding the personality of each particular fracture may range from very

straightforward to a quite complicated process [3].

The most commonly used classification system is that published by Neer. this classification system describes fractures as one, two, three or four-part fractures depending on the number of displaced segments, displacement is considered as being greater than one centimeter or more than 45° angulation of a segment relative to another [4]. Displaced three-part and four-part fractures markedly alter the articular congruity of the glenohumeral joint and have the highest likelihood of disrupting the major blood supply to the proximal humerus [5]. Surgical management of these fractures includeing: close reduction and percutaneous pinning, open reduction and internal fixation by multiple options including: plate and screws, fixed-angle device, transosseous suture fixation and locked intramedullary nail. The surgical technique of close reduction and percutaneous pinning was first described by Bohler [6] for the treatment of proximal humerus fracture in paediatric age group; however, this technique has been adopted for adult fractures as well. Percutaneous techniques reduce stripping and dissection around the shoulder joint, therefore, there is less risk of endangering the blood supply of the humeral head. Moreover, there is less scarring around the scapulohumeral joint thus the postoperative rehabilitation is easier.

The purpose of this study is to report the functional, clinical, and radiological outcomes of percutaneous pinning technique in two-part and three-part proximal humerus fractures in adults.

Patients and Methods

This case-series study is designed to report the outcomes of percutaneous pinning technique in two-part and three-parts proximal humerus fracture. Two emergency hospitals were involved in this study which are Balsam Private Hospital and West-Erbil Emergency Hospital in Erbil city. The operations were performed from January 2018 to February 2019. The data of this study were collected in the follow-up visit one year after the operations.

The inclusion criteria are adult patients (more than 18 years), two-part and three-part Neer fractures and the patients who had close fractures. While the exclusion criteria consist of: paediatric patients, proximal humerus fracture which has an extension to the shaft, pathological fractures, fractures with nerve and/or vascular injuries to the involved limb.

Informed consent was taken from all patients involved in this study and the research protocol had been accepted by the ethical committee of the Kurdistan Board of Medical Specialities which ensured the adherence of this study to the ethical principles.

Surgical techniques

After admission, all patients underwent a thorough clinical examination. The fracture was assessed by anteroposterior (AP) and axillary view (when possible). Moreover, a computed tomography scan (CT-Scan) was performed for all the cases. All these operations were done within one week after admission.

The decision of operation was made by a senior consultant, and the patients were informed about the operation, the possible

outcomes and other alternative treatments. The operations were done under general anaesthesia in a semi-sitting (beach-chair position). An important step in patient positioning was that to put the involved scapula over the edge of the table to make an appropriate space for the fluoroscopy which was positioned to make orthogonal imaging of the proximal humerus possible and was used to guide fracture reduction and placement of percutaneous fixation. Proper patient positioning and ensuring that fluoroscopy images views are accepted, before the draping, is an essential step in this procedure.

Close reduction, as described by Jaberg et al [7], was an attempt in all the cases, and mini-invasive techniques using blunt instruments or a Steinmann-pin or K-wires were used to align the main parts aligned with the shaft.

To achieve the fixation, firstly two 2.5mm K-wires were passed through the lateral aspect of humeral shaft, above deltoid insertion (green lines), then another one is placed through the anterior cortex of the humeral shaft to the humeral head (the blue line); in case of greater tuberosity was fractured and displaced, then two pins were inserted antegrade from the greater tuberosity to the medial neck(red lines), sometimes a third K-wire was added to fix the greater tuberosity to the humeral head. In addition, more K-wires were added to achieve a more stable fixation if the fracture configuration or the bone quality requires more stability. The K-wires were carefully bent and cut 2 cm outside the skin and proper dressing was applied (Figure 1) and (Figure 2). The arm was held in an arm-sling. and an abduction pillow was used in all the patients to keep the arm in an abducted valgus position.

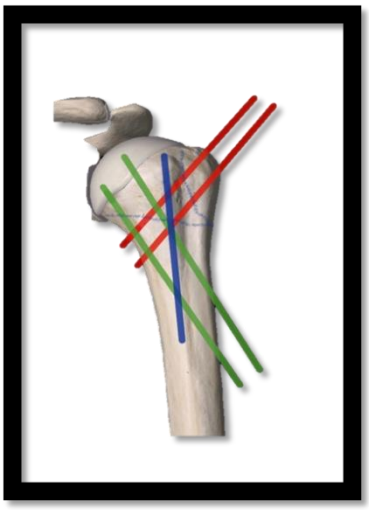

Figure (1): The techniques of percutaneous fixation

Postoperative care and rehabilitation

From the first postoperative day the patients were encouraged to start active exercises of the elbow, forearm, wrist and hand to avoid stiffness of these joints. Meanwhile, the shoulder joint was immobilized (in an arm-sling and abduction pillow) for 4 weeks when the first radiograph was taken and loose wires were removed (if present). Moreover, the K-wires were

removed between week 6 and 8 postoperatively. At the sixth week, passive and active exercises were started and the strength was increased gradually. Thereafter, these patients were assessed in the third and sixth months after the operation. At one year postoperatively, we assessed each patient for the measures that will be mentioned in the later lines.

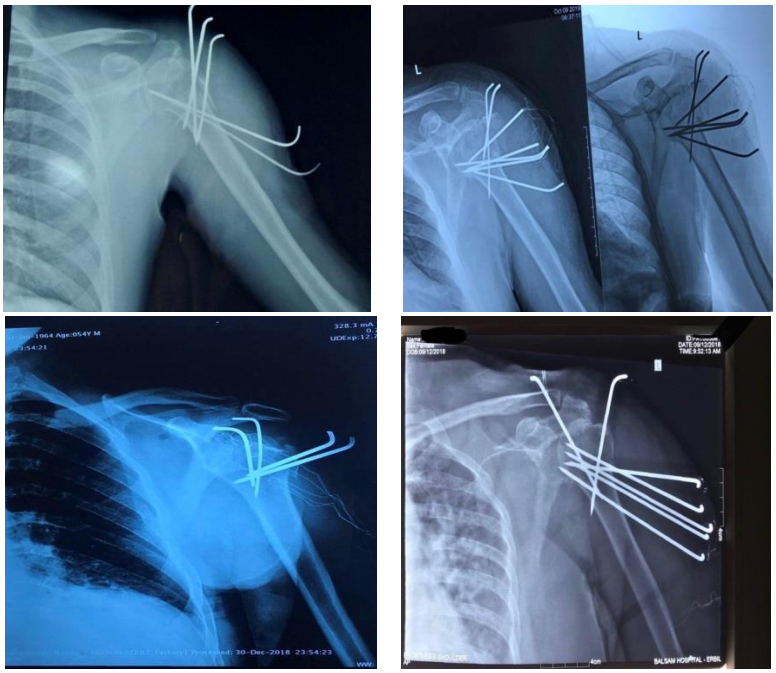

Figure (2): Postoperative images using percutaneous reduction technique and fixation by K-wires

Evaluation after one year

At a minimum of one year after surgery, the follow-up assessment for this study was performed. All patients filled questionnaire forms regarding their shoulder joint function and pain. A standard goniometer was used to assess the active and passive range of movement at the shoulder joint. For pain evaluation, the pain numeric scale, ranging from 0 (no pain) to 10 (the worst pain), was used. Rotator cuff muscles strength were measured manually, and the power of shoulder abduction was quantified with an electronic dynamometer. The functional outcome of the shoulder was determined by calculating the American Shoulder and Elbow Surgeons (ASES) [8] score and the Constant score [9] and for each patient.

Radiographs were taken at the annual follow-up including anteroposterior (AP), true AP, and lateral axillary views, each radiograph was assessed for signs of avascular necrosis, mal-union and osteoarthritis (OA) of the glenohumeral joint. Avascular necrosis was determined by the presence of a discrete area of sclerosis or collapse in the humeral head. Osteoarthrosis was classified to be grade-one if the joint space was narrowed, grade-two if there were osteophytes of less than 3 mm, grade-three if significant subchondral sclerosis was present in addition to osteophytes, and grade-four in the presence of greater changes [10]. Moreover, Neck-shaft-angle (NSA) on true AP view was used to determine the presence of malunion which was defined by a Neck-

shaft angle less than 120 or more than 160 degrees. The NSA was calculated by measuring the angle between the intersection of a line along the axis of the proximal humerus and another line which is perpendicular to the anatomic neck of the humerus.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 25). Chi-square test of association was used to compare proportions. Fisher's exact test was used when the expected count of more than 20% of the cells of the table was less than 5. Mann Whitney test was used to compare the mean ranks of the parameters of the two groups (two and three parts fractures). A p-value of ≤ 0.05 was considered statistically significant.

Results

Twenty-five patients with fracture humerus were included in the study. The highest proportion of the patients (44%) were aged 55-64 years old, and more than half (60%) were females. The majority (76%) of the patients were right-handed, and the involved side was the right side in 60% of the patients. Regarding the type of the fracture, it was a two-part fracture in 52% of the patients, and a three-part fracture in 48% of the cases.

Osteoarthritis developed in 16% of the patients. None of the patients developed non-union or avascular necrosis. Regarding the mean (± SD) neck-shaft angle, it was 132.04 ± 10.79^0 Table (2).

Physical Examination

On examination, the majority of the patients achieved either thoraco-lumber (40%) or thoracic (44%) internal rotation, but there was no significant (p = 0.191) difference between the patients with two and three parts fractures as presented in Table 4. A round half (48%) of the patients achieved 160-180^0 forward flexion but the difference between the two groups was not significant (p = 0.158). Regarding the external rotation, 76% of the patients were normal (92.3% in the two parts fractures and 58.3% in the three parts fractures), but the difference was not significant (p = 0.073). The mean numerical pain score of the entire group was 1.04/10 with more than half (56%) of the patients had only mild pain, scores less than or equal to 3/10, (46.2% in the two parts fractures and 66.7% in the three parts fractures), again the difference was not significant (p = 0.302). none of the patients had a pain sore more than 3/10. The parameters of the functional outcomes are presented in Table (3).

Outcomes Evaluation

The mean ASES score of the whole group was 87.27 (±3.39) while the mean rank of the ASES score of the two-part fracture was significantly higher than the mean rank of the three-parts fracture (p = 0.001). The Constant score of the whole group was 79.04 (±5.12) and it was higher in the two-part group but the difference with the three-part was not significant (p = 0.913) as presented in Table (5).

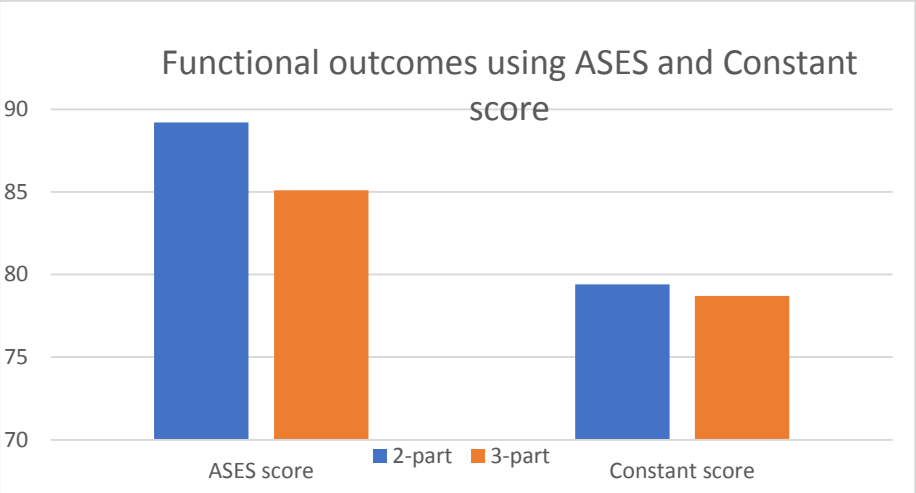

Figure (3): Functional outcomes according to the fracture

The ASES score was significantly higher among those with no osteoarthritis (OA) than patients with OA (p = 0.002). The same pattern was noticed with the Constant Score but the difference was not significant (p = 0.352). The pain was significantly higher among patients with OA compared with patients who didn't develop OA (p = 0.001) as presented in Table (6). Table (7) shows that 33.3% of patients with three parts fracture developed OA in the glenohumeral joint in the form of irregularity and narrowing of the joint space, while none of the patients with two parts fracture developed OA (p = 0.039).

Only 16% of the patients developed malunion (Neck-shaft-angle below 120 degrees), but the difference was not significant between the two groups (p >0.999). When comparing the parameters of the functional outcome (ASES score, constant score, and pain scores) between patients with mal-union and patients with union, no significant differences were detected (p = 0.765, p = 0.823, and p = 0.610 respectively) as presented in Table (8).

Complications

Regarding postoperative complications, none of the patients developed nerve or vascular injuries, however, pin-loosening was observed in one patient that required pin removal 25 days after the operation. Moreover, one patient developed a pin-tract infection, this presented as a slight amount of discharge around one k-wire which did not affect the stability of the fracture and was treated by removal of the K-wire, wound care, and antibiotics guided by culture and sensitivity. In addition, no pin-migration or deep infections happened to any of these patients.

Table (1): Basic characteristics of the studied sample

	No.	(%)
Age (years)		
< 55	6	(24.0)
55-64	11	(44.0)
≥ 65	8	(32.0)
Gender		
Male	10	(40.0)
Female	15	(60.0)
Dominant side		
Right	19	(76.0)
Left	6	(24.0)
Involved side		
Right	15	(60.0)
Left	10	(40.0)
Fracture type		
Two parts	13	(52.0)
Three parts	12	(48.0)
Total	25	(100.0)

Table (2): Radiographic outcomes

	No.	(%)
Radiographic evaluation		
No osteoarthritis	21	(84.0)
Osteoarthritis	4	(16.0)
Fracture union		
Yes	25	(100.0)
No	0	(0.0)
Avascular necrosis		
Yes	0	(0.0)
No	25	(100.0)
Neck shaft angle		
Mean (±SD)	132.04	(±10.79)

Table (3): Physical examination and functional outcomes of the entire group

	Mean	(±SD)	Median	Min.	Max.
Forward flexion	155.60	(±13.33)	155.00	130.00	175.00
External rotation	58.60	(±12.12)	60.00	40.00	80.00
Abduction	162.80	(±10.01)	165.00	145.00	180.00
Pain (numerical rating scale)	1.04	(±1.14)	1.00	0.00	3.00
ASES score	87.24	(±3.39)	87.00	83.00	97.00
Constant score	79.04	(±5.12)	80.00	71.00	95.00

Table (4): Physical examination by type of fracture

	Two parts		Three parts		Total		
	No.	**(%)**	**No.**	**(%)**	**No.**	**(%)**	**p**
Internal rotation							
Thoracic	8	(61.5)	2	(25.0)	11	(44.0)	
Thoraco-lumber	4	(30.8)	6	(50.0)	10	(40.0)	
Mid-lumber	1	(7.7)	1	(8.3)	2	(8.0)	
Gluteal	0	(0.0)	2	(16.7)	2	(8.0)	0.191
Forward flexion							
$< 160^0$	5	(38.5)	8	(66.7)	13	(52.0)	
$160\text{-}180^0$	8	(61.5)	4	(33.3)	12	(48.0)	0.158
External rotation							
$< 45^0$	0	(0.0)	2	(16.7)	2	(8.0)	
$45\text{-}90^0$	13	(100.0)	10	(83.3)	23	(92.0)	0.220*
Abduction							
< 160	1	(7.7)	5	(41.7)	6	(24.0)	
Normal	12	(92.3)	7	(58.3)	19	(76.0)	0.073
Pain							
No pain	7	(53.8)	4	(33.3)	11	(44.0)	
Mild	6	(46.2)	8	(66.7)	14	(56.0)	0.302
Total	13	(100.0)	12	(100.0)	25	(100.0)	

Table (5): Functional outcome as assessed by the ASES score and constant scores

	Mean	**(±SD)**	**Median**	**Minimum**	**Maximum**	**mean rank**	**P***
ASES score							
Two parts	89.2	(±3.3)	88.0	85.0	97.0	17.7	
Three parts	85.1	(±1.8)	84.5	83.0	88.0	7.9	0.001
Constant score							
Two parts	79.4	(±6.4)	80.0	71.0	95.0	13.15	
Three parts	78.7	(±3.6)	79.0	73.0	85.0	12.83	0.913

Table (6): Effect of osteoarthritis on the outcome

	Mean	**Median**	**(±SD)**	**Min.**	**Max.**	**Mean rank**	**P***
ASES score							
No osteoarthritis	88.00	87.00	(±3.16)	84.00	97.00	14.95	0.002
Osteoarthritis	83.25	83.00	(±0.50)	83.00	84.00	2.75	
Constant score							
No osteoarthritis	79.48	80.00	(±5.30)	71.00	95.00	13.60	0.352
Osteoarthritis	76.75	76.00	(±3.77)	73.00	82.00	9.88	
Pain							
No osteoarthritis	0.67	0.00	(±0.80)	0.00	2.00	11.00	0.001
Osteoarthritis	3.00	3.00	(±0.00)	3.00	3.00	23.50	

Table (7): Radiographic outcome by type of fracture

	Two parts		Three parts		Total		
	No.	**(%)**	**No.**	**(%)**	**No.**	**(%)**	**p**
Radiographic evaluation							
No osteoarthritis	13	(100.0)	8	(66.7)	21	(84.0)	
Osteoarthritis	0	(0.0)	4	(33.3)	4	(16.0)	0.039*
Mal-union							
Mal-union	2	(15.4)	2	(16.7)	4	(16.0)	
Union	11	(84.6)	10	(83.3)	21	(84.0)	>0.999*
Total	13	(100.0)	12	(100.0)	25	(100.0)	

Table (8): Effect of malunion on functional outcome

	Mean	**Median**	**(±SD)**	**Min.**	**Max.**	**Mean rank**	**P***
ASES score							
Mal-union	86.75	86.00	(±3.10)	84.00	91.00	12.00	
Union	87.33	87.00	(±3.51)	83.00	97.00	13.19	0.765
Constant score							
Mal-union	78.75	79.50	(±4.65)	73.00	83.00	13.75	
Union	79.10	80.00	(±5.31)	71.00	95.00	12.86	0.823
Pain							
Mal-union	1.25	1.00	(±1.26)	0.00	3.00	14.63	
Union	1.00	1.00	(±1.14)	0.00	3.00	12.69	0.610

Discussion

Percutaneous reduction and pinning techniques lead to outstanding results and low complication rates in the management of two-part and three-part proximal humerus fracture. The advantages of this technique include less soft-tissue dissection, reliable healing, better cosmetic outcome and lower costs than open techniques due to relatively cheap instruments. These techniques require an accurate understanding of the fracture anatomy, and the deforming forces created by the muscles around the shoulder joint. The surgical skills of this procedure have a significant learning curve.

This study shows that most of the patients have returned to nearly normal functional level with least pain scores. The ASES score was significantly higher in the two-part group. The advantages of this technique include less soft-tissue dissection, a reliable healing, better cosmetic outcomes, and lower costs than open techniques due to relatively cheap instruments.

In this study, none of the cases developed avascular necrosis or non-union, while only 14% of the cases (all from the three-part group) developed osteoarthritis in the glenohumeral joint, this can be explained by almost anatomic reduction can be achieved by percutaneous techniques while decreasing the vascular compromise of the head of the humerus. Moreover, 16% of the sample developed a varus mal-union with statistically non-significant effect on the functional scores.

Many researchers have reported the outcomes of minimally invasive techniques to the management of the proximal humerus fracture. Soete et al presented the outcomes in a case series of 31 patients who had undergone percutaneous reduction and fixation of proximal humerus fractures, and good results were presented [11]. Jay D. Keener et al reported the outcomes after percutaneous reduction and fixation of proximal humeral fractures, the mean Constant score of the two-part and there-part groups were 78.7 and 78.6 respectively while the ASES score of the two-part was 87.9 and for the three-part group was 85.1. Moreover, osteoarthritis developed in 17% of the cases and no avascular necrosis developed in the two-part and three-part fracture groups [12]. Jaberg et al presented a case series of 48 patients with different types of proximal humerus fractures which were reduced and fixed percutaneously, they reported excellent or good results by using the Salliant scale after three years of follow-up with only a 4% rate of avascular necrosis in the humeral head [7]. In a case series of 27 patients who were above the age of fifty years, Eid et al [13] described a percutaneous technique in these types of fractures based on using Shanz screws in combination with K-wires, the Constant Score of the two-part and three-part groups were 71.9 and 65.5 respectively, while the pin-tract infection was the most common complication. Comparing with other methods of fixation, Jaura et al [14] compared the functional outcomes using Constant and VAS scores in thirty patients who had undergone fixation by Proximal Humerus Internal Locking System (PHILOS) versus another 30 patients who were treated by percutaneous K-wire fixation , the mean Constant Score in the first group was 84.6 points while in the K-wire group was 76.4, he concluded that internal fixation using PHILOS plate enabled the patients to start physiotherapy sooner, however, the functional results of both groups were acceptable.

We believe that percutaneous reduction and fixation techniques require an accurate understanding of the fracture anatomy and the deforming forces created by the muscles around the shoulder joint. The surgical skills of this procedure have a significant learning curve. Therefore, we believe that preoperative Computed Tomography (CT scan) is of paramount importance in this setting to get a proper assessment of the fracture type and to detect areas of comminution. Moreover, regular follow-up and ensuring appropriate physiotherapy during the rehabilitation period is essential to achieve a desired functional outcome.

Regarding the limitation in this study, a longer duration of follow-up could have revealed a better assessment of the long-term complications. In addition, a larger sample size would have demonstrated a better evaluation of these techniques against other variables like age, gender, and type of fracture.

Conclusions

Percutaneous close reduction and pinning is a reliable surgical technique in the management of closed two-part and three-part proximal humerus fractures in adults. Appropriate preoperative planning is important to achieve a successful surgical

result, and regular postoperative follow-up and rehabilitation are essential to get an optimum functional outcome.

Recommendations

We suggest further research work in this field in prospective comparative studies comparing methods of open and close techniques in a larger sample, at multi-center levels, and for a longer duration of follow-up.

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