Al-Azhar International Medical Journal

Volume 5 | Issue 2 Article 28

2024
Section: Orthopedics

PHILOS Plating Versus Percutaneous K-Wire Fixation in Proximal Humerus Fractures in the Elderly

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How to Cite This Article

El-Geoshy, Aly Mohammed; Abdalla, Usama Gaber; and Gaafar, Ehab Khaled (2024) "PHILOS Plating Versus Percutaneous K-Wire Fixation in Proximal Humerus Fractures in the Elderly," *Al-Azhar International Medical Journal*: Vol. 5: Iss. 2, Article 28.
DOI: https://doi.org/10.58675/2682-339X.2270

ORIGINAL ARTICLE

PHILOS Plating Versus Percutaneous K-Wire Fixation in Proximal−Humerus Fractures in the Elderly

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Abstract

Objectives: **To compare the results of percutaneous K-wires versus PHILOS plate in terms of activity, shoulder function, radiological assessment, and complications.**

Patients and methods: **Thirty patients were randomly divided into two groups with the closed envelop method between July 2021 and July 2022. Group A, the K-wires group, consisted of seven males and eight females, with a mean age of 68 years, while group B, the PHILOS group, comprised nine males and six females, with a mean age of 66 years. The included patients were elderly individuals with recent, closed fractures as two, three, or four-part fractures. Excluded patients were open fractures, old, nonunited, malunited, or patients with contraindications of general anesthesia.**

Results: **Both groups achieved radiological union, and functional results at 1 year using the Constant−Murley score. The mean operative time in the plate group is around two times that of the K-wires group (153 and 79 min) and blood loss was four times more in the plate group (413 and 86 ml). The plating group had a better neck-shaft angle (mean was 128° and 118° for K-wires). There were three (20%) cases of pin loosening and malunion in the K-wires group, two (6.7%) cases of deep infection in the plate group that required debridement in one, and reosteosynthesis by wires in the other one. The mean Constant score after 1 year was nearly the same (K-wires 91 and plates 88.8 points).**

Conclusion: **Percutaneous K-wires give good results in comparison to ORIF with PHILOS with less operative time and intraoperative blood loss with no risk of deep infection.**

Keywords: K-wires, PHILOS, Proximal−humerus fracture

1. Introduction

Fractures of the proximal−humerus account for ~5% of all skeletal fractures. Following fractures of the hip and distal radius, they are the third most frequent type of fracture and is extremely common in the elderly due to osteoporosis.[1]

There are wide varieties of proximal−humerus fracture treatment in old people that include percutaneous K-wire fixation and closed reduction that offers a good position and stability with the advantage of minimal soft tissue damage and lower risk of head avascular necrosis (AVN); however, there should be a close follow-up in the first 4 weeks, as secondary displacement can occur in this period. It may also be associated with pin tract infection and a long period of recovery.[2]

ORIF with PHILOS is the most stable method of fixation with the best reduction as the open approach allows accurate reduction and rigid stabilization of tuberosities with the advantage of using supplementary nonabsorbable sutures in the rotator cuff.[3] Nevertheless, it has some drawbacks such as excessive dissection of the soft tissues and loss of blood with an increased danger of neurovascular injuries and a higher risk of AVN of the humeral head.[4] There is also an increased risk of screw penetration into the glenohumeral joint, both primary and secondary.[5]

MIPO through the deltoid splitting approach allows less soft tissue handling with preservation of blood supply and direct visualization of the GT fragment.[6]

Intramedullary nailing also preserves blood supply with less soft tissue injury, newer designs with

Accepted 16 October 2023.
Available online 7 June 2024

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https://doi.org/10.58675/2682-339X.2270

polyaxial screws have more stability than earlier designs. The point of insertion may violate the rotator cuff which can lead to postoperative pain, and involvement of the lateral cortex and tuberosities makes intramedullary nailing a less favorable option.[6]

Arthroplasty is indicated when adequate reduction or fixation cannot be achieved as in head-splitting fractures with more than two pieces or four-part fracture dislocation, below 60 years arthroplasty is seldom necessary. Reversed shoulder arthroplasty is indicated for patients older than 70 years with unfunctioning rotator cuff and intact deltoid.[5]

External fixator is considered today as a valid option for proximal–humerus fracture fixation with blood supply preservation in an early range of motion, but it is rarely used.

The goal in all options is anatomical reduction, good mechanical stability, and good functional outcomes while preserving the blood supply of the head.[5]

Over the past few years, there has been always a tendency in orthopedic surgery toward minimal dissection, and the current tendency is closed reduction with limited fixation, which results in less damage to soft tissues and a decreased risk of the humeral head AVN, contrasted to open reduction and extensive dissection of internal fixation.[7]

The purpose of this work is to contrast the results of proximal–humerus fracture fixation with percutaneous K-wires versus ORIF with PHILOS plate in terms of returning to prefracture level of activity, shoulder function, radiological assessment, and complications.

2. Patients and methods

This prospective, randomized, comparative work among closed reduction and percutaneous fixation versus open reduction and plate fixation in the management of proximal–humerus fractures in the elderly was performed at Al-Azhar University Hospitals in Cairo from July 2021 to July 2022. Thirty individuals suffering from proximal–humerus fractures were included and randomly divided into two equal groups with the closed envelope method, where 15 of each treatment option were allocated into sealed opaque envelopes, once a patient had consented to enter the trial an envelope was opened and the patient is offered the allocated option in the envelope.

2.1. Inclusion criteria

Elderly individuals over 60 years of age with closed recent proximal–humerus fractures, two parts, three parts, and four parts.

2.2. Exclusion criteria

(1) Open fractures.
(2) Medical contraindications to general anesthesia.
(3) Patients with old, nonunited, malunited fractures.
(4) Pathological fractures.
(5) Individuals with bone tumors, either metastatic or primary.

2.3. Management

General examination to detect any associated injuries was conducted. Local examination: the skin was examined for wounds, abrasions, ecchymosis, deformity of the fracture, dislocation was looked for, and neurological and vascular state of the injured limb was examined. Proper imaging included plain radiographic anteroposterior and lateral views, and computed tomography scans in selected cases.

All participants gave their informed consent for inclusion before they voluntarily participated in the study. The study was conducted in accordance with the Declaration of the Ethics Committee of Al-Azhar and after the protocol approval, no harm was done nor assessment of irrelevant components with complete confidentiality for participants' data.

2.4. Operative technique

2.4.1. For group A patients

Kirschner wires of 2–2.5 mm diameter without threads were prepared. General anesthesia was administered and the patient was positioned semi-sitting with the injured arm left hanging from the edge of the table. After scrubbing, the reduction was done under fluoroscopic guidance. When a proper reduction could not be achieved, stab incisions were performed inferior to the anterolateral corner of the acromion and just beneath the fractures. Through this an elevator is produced and advanced to the medial calcar to manipulate the fragments. A Kirschner wire was inserted to hold the fractured pieces. The ideal configuration of the wires is two wires from the greater trochanter to the shaft at first, then two wires from the lateral or antrolateral aspect of the shaft to the head, and one wire from the anterior aspect directed upward inside the head. The wires were bent and cut outside the skin dressings applied on their entries. The patient was delivered from the operating room in an arm sling (Fig. 1).

Fig. 1. (A) K-wires. (B) Semi-sitting position, image intensifier coming from the opposite side. (C) Spatula for reduction. (D) Percutaneous K-wire entry. (E) Checking of reduction under image intensifier. (F) Wires bending outside the skin. (G) Postoperative radiograph. (H): Radiograph after 1 year. (I): 1 year clinical follow-up.

2.4.2. For group B patients

The PHILOS plate and K-wires were prepared, and the patient underwent general anesthesia in a semi-sitting posture. The deltopectoral approach was used: a 12–14 cm long skin incision was made, starting from the coracoid process down to the shaft of the proximal humerus. The deltopectoral groove was exposed marked by cephalic vein and was bluntly dissected between and beneath the pectoralis and deltoid muscles after being retracted laterally or medially and opened along the groove. We identify the conjoint tendon and the coracoid process. The clavipectoral fascia was cut below the coracoacromial ligament and lateral to the conjoint tendon. After this dissection: the morphology of the fracture can be identified. The reduction was done by manipulating the arm hanging outside the operating table; in some cases, we passed thick ethibond sutures in the substance of the infraspinatus, supraspinatus, and subscapularis muscles. By manipulating these sutures we could rotate the head to reach the best position of reduction and finally fixed into special holes in the plate. Thick wires were used to maintain the reduction. The plate was applied and fixed by a screw. The plate was placed ~10 mm distal to the rotator cuff attachment on the upper edge of the greater tuberosity. Screws are applied in the calcar humeral to prevent varus collapse. A suction drain was applied, and subcutaneous and skin closure were performed (Fig. 2).

3. Results

Statistical analysis: recorded data were analyzed using the Statistical Package for the Social Sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± SD. Qualitative data were expressed as frequency and percentage.

The following tests were done:

(1) Independent sample *t*-test of significance was used when comparing two means.
(2) A paired sample *t*-test of significance was used when comparing related samples.
(3) χ^2 test of significance was used to compare proportions between two qualitative parameters.
(4) The confidence interval was set to 95%, and the margin of error accepted was set to 5%. So, the *P* value was considered significant as the follows:

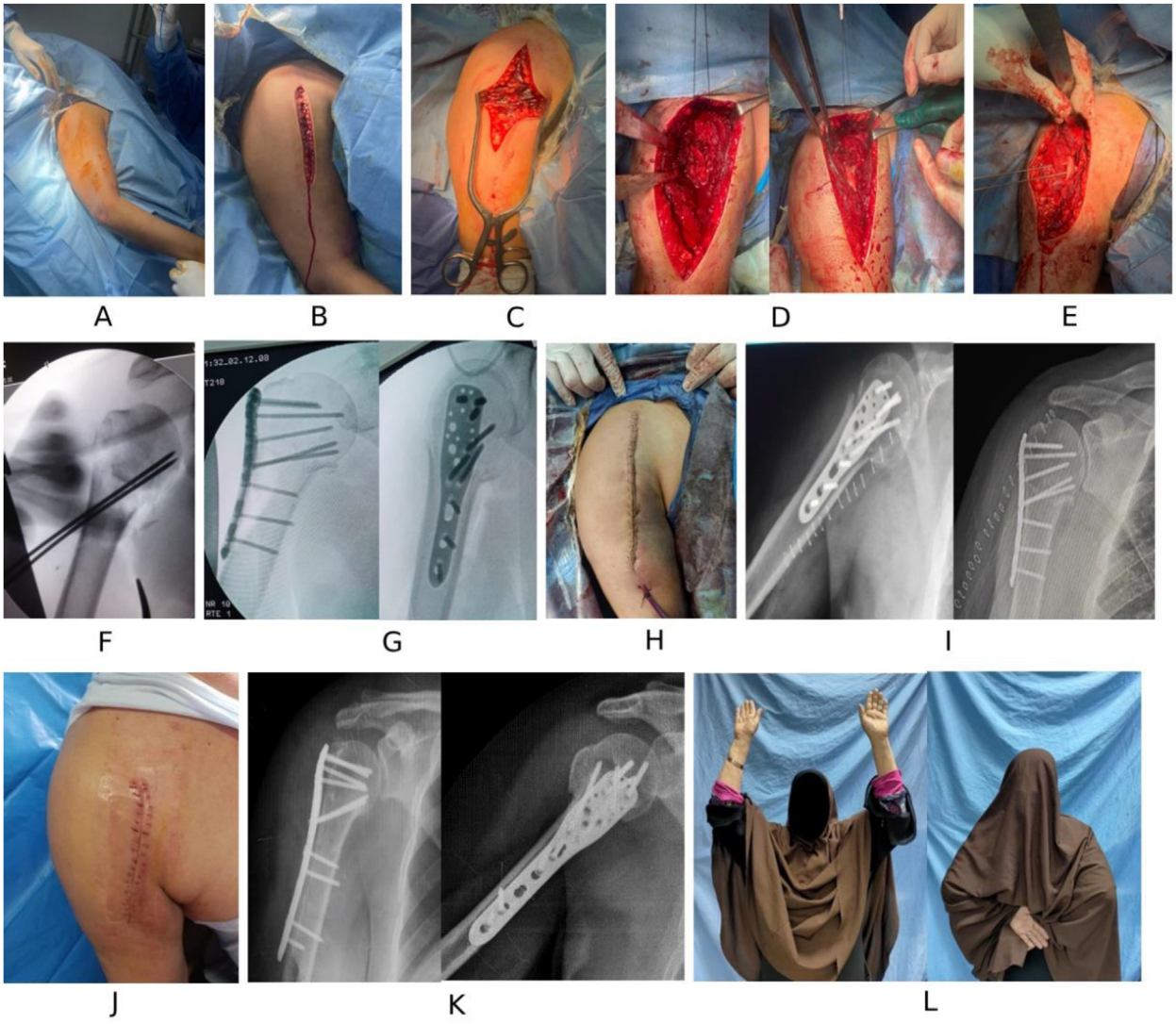

Fig. 2. (A) Semi-sitting position and position of the image intensifier. (B) Skin incision. (C) Dissection along the deltopectoral groove. (D) Opening the groove down to the fracture and rotator cuff sutures. (E) Passing two preliminary K-wires to hold the reduced fracture. (F) Checking the reduction under the image intensifier. (G) Putting the plate and screws in the optimal direction and checking stability under an image intensifier. (H) Anatomical closure and drain. (I) Postoperative radiograph. (J) After removal of skin stables. (K) 1-year follow-up radiograph after complete fracture consolidation. (L) 1-year clinical follow-up.

(a) *P* value less than 0.05 was considered significant.
(b) *P* value less than 0.001 was considered as highly significant.
(c) *P* value more than 0.05 was considered insignificant.

Group A included 15 patients, seven men and eight women with a mean age of 68 years. According to the Neer Classification system, there were six patients with two-part fractures, eight patients with three-part fractures, and one patient with four-part fractures. All underwent closed reduction and percutaneous fixing with K-wires and group B had 15 individuals, nine men and six women with a mean age of 66 years. Regarding the Neer Classification there were seven patients with two-part fractures, eight patients with three-part fractures. All underwent ORIF with PHILOS. Functional results at 1 year were assessed using the Constant–Murley score.

All patients in both groups achieved radiological union Functional results at 1 year were assessed using the Constant–Murley score The mean operative time in the plate group is around two times that of the K-wires group (153 and 79 min) and loss of blood was four times more in the plate group (413 and 86 ml). The plating group had a better neck-

shaft angle (mean was 128° and 118° for K-wires). There were three (20%) cases of pin loosening and malunion in the K-wires group but no instances of deep infection, in the plate group there were two (6.7%) cases of deep infection that required debridement in one and reosteosynthesis by wires in the other one. The mean Constant score after 1 year was nearly the same (K-wires 91 and plates 88.8 points).

Table 1 shows no statistically significant variance among groups as regards demographic data and Neer Classification.

Table 2 shows highly statistically significant variance among groups as regards intraoperative blood loss (min).

Table 3 shows highly statistically significant differences through follow-up visits in Constant score in both groups.

Table 4 shows statistically significant variance among groups as regards the Constant score after 1 month and 3 months while the rest have insignificant differences.

Table 5 shows statistically significant variance among groups as regards neck-shaft angle.

Table 1. Comparison among groups as regards demographic data and Neer Classification.

Demographic data	Group A K-wires ($N = 15$) [n (%)]	Group B Plates ($N = 15$) [n (%)]	Total	$t/\chi^{2\#}$	P value
Sex					
Female	8 (53.3)	9 (60.0)	17 (56.6)	0.136	0.713
Male	7 (46.7)	6 (40.0)	13 (43.3)		
Age (years)					
Mean ± SD	68.6 ± 4.7	65.7 ± 4.2	69 ± 4.4	2.055	0.163
Range	62–78	62–77	62–78		
Occupation					
Clerk	4 (26.7)	1 (6.7)	5 (16.7)	2.492	0.288
Housewife	5 (33.3)	8 (53.3)	13 (43.3)		
Manual worker	6 (40)	6 (40)	12 (40)		
Age groups					
<63 years	3 (20)	4 (26.7)	7 (23)	0.868	0.648
63–70 years	8 (53.3)	9 (60)	17 (57)		
>70 years	4 (26.7)	2 (13.3)	6 (20)		
Neer Classification					
Two parts	6 (46.7)	7 (46.7)	13 (43.3)	1.067	0.587
Three parts	7 (46.7)	8 (53.3)	15 (50)		
Four parts	1 (6.7)	0	1 (3.3)		
Three parts with dislocation	1 (6.7)	0	1 (3.3)		

Table 2. Comparison among groups as regards intraoperative blood loss (ml).

Blood loss (ml)	Group A: K-Wires ($N = 15$) [n (%)]	Group B: plates ($N = 15$) [n (%)]	t-test	P value
Mean ± SD	86.67 ± 34.98	413.33 ± 151.74	66.013	0.001*
Range	50–170	250–750		

* Statistically significant difference.

Table 3. The progression of Constant scores in both groups.

CS	Group A: K-wires (mean ± SD)	Mean difference	Paired sample t-test	
			t	P value
After 1 month	26.80 ± 3.63			
After 3 months	54.80 ± 15.71	28.00	−8.914	<0.001**
After 6 months	86.40 ± 11.27	59.60	−17.841	<0.001**
After 1 year	91.53 ± 7.50	64.27	−29.005	<0.001**
Constant score	Group B: plates (mean ± SD)	Mean difference	Paired sample t-test	
			t	P value
After 1 month	34.67 ± 9.99			
After 3 months	66.87 ± 14.63	−32.20	8.830	<0.001**
After 6 months	84.60 ± 8.91	−50.33	23.143	<0.001**
After 1 year	88.47 ± 5.18	−54.20	26.441	<0.001**

** Highly statistically significant difference.

Table 4. Comparison among groups as regards the Constant score.

CS	Group A: K-Wires ($N = 15$)	Group B: plates ($N = 15$)	*t*-test	*P*-value
After 1 month				
Mean ± SD	26.80 ± 3.63	34.67 ± 9.99	8.216	0.008*
Range	19–32	19–48		
After 3 months				
Mean ± SD	54.80 ± 15.71	66.87 ± 14.63	2.178	0.038*
Range	32–85	29–84		
After 6 months				
Mean ± SD	86.80 ± 11.27	84.60 ± 8.91	0.351	0.558
Range	59–98	66–93		
After 1 year				
Mean ± SD	91.53 ± 7.50	88.47 ± 5.18	1.697	0.203
Range	74–98	80–93		

* Statistically significant difference.

Table 5. Comparison among groups as regards neck-shaft angle at final follow-up.

Neck-shaft angle (°)	Group A: K-wires ($N = 15$)	Group B: plates ($N = 15$)	*t*-test	*P* value
Mean ± SD	118.00 ± 15.21	128.00 ± 10.32	4.440	0.044*
Range	90–135	100–140		

* Statistically significant difference.

Table 6. Comparison between groups according to complications.

Complications	Group A: K-wires ($N = 15$)	Group B: plates ($N = 15$)	*t*-test	*P* value
Loss of reduction and malunion	3 (20.0)	0	3.333	0.048*
Bleeding from the surgical site	1 (6.7)	0	1.034	0.309
Inferior subluxation	1 (6.7)	1 (6.7)	0.000	1.000
Stiffness	1 (6.7)	1 (6.7)	0.000	1.000
Deep infection	0	2 (13.3)	1.034	0.309
Radial nerve injury	0	1 (6.7)	1.034	0.309
Pin tract infection	3 (20.0)	0	3.333	0.048*
None	7 (46.7)	11 (73.3)	2.223	0.136

* Statistically significant difference.

Table 6 shows statistically significant variance among groups as regards loss of reduction and malunion and according to pin tract infection.

4. Discussion

Approximately 5% of all fractures are proximal–humerus fractures, which rank as the second most frequent fractures in the upper extremities.[8] Following fractures of the distal radius and vertebrae, it is the third most frequent osteoporotic fracture of bones in older individuals with osteoporosis.[8] Treatment of these fractures is always challenging including open techniques and minimally invasive techniques.[9]

Although ORIF permits excellent bone exposure and the chance of anatomical reduction, it interferes with the head's blood flow, raising the possibility of the humeral head' AVN and slowing down the process of bone healing. However, closed reduction and percutaneous pinning carry the advantages of less injury to the soft tissues resulting in better healing and better scar and cosmetic appearance.[10]

Many studies in the literature were performed to discuss the results of percutaneous and open techniques for management of fractures of the proximal–humerus. For example: Harrison *et al.*[11] and Fenichel *et al.*[7] studied retrospectively the results of closed reduction and percutaneous pinning. Siddalingamurthy *et al.*[12] and Chowdary *et al.*[13] studied the results of open reduction and plating, while Jaura *et al.*[2] and Ortmaier *et al.*[14] published the outcome of their work comparing percutaneous and open techniques. In 2014 and 2015, two comparative studies between closed pinning and open plating were published by Jaura and colleagues and Ortmaier and colleagues both of them had 60 patients: 30 treated by percutaneous K-wires and 30 treated

by open plating. Jaura and colleagues had 60 patients with a mean age of 63 years (range, 62–65 years) and follow-up for 12 months. In the current study, we had 30 patients divided into 15 patients treated by closed reduction and percutaneous pinning and another 15 treated by ORIF. The follow-up period was 1 year, comparable to other studies. The mean age of our study was 48 years (range, 25–70 years), which is comparable to other studies in the literature.

In most of the literature, the operative time in the plate fixation is double that for the percutaneous wire fixation on average. According to Jaura and colleagues closed reduction and percutaneous pinning last ~50 min (range, 35–70 min), and for Ortmaier and colleagues the mean operation time was 72.1 min (range, 31–206 min). In our study, the mean operative time for K-wire fixation was 79 min (range, 40–135), which is comparable to the range of the literature. However, the mean operative time for open reduction and plate fixing: according to the Jaura and colleagues study was 100 min (range, 80–120 min), and for Ortmaier and colleagues the mean operation time was 117.3 min (range, 77–208) for the plate group.

In our study, the mean operative time for plate fixation was 153 min (range, 105–195), which is relatively longer than other studies by about 30 min but carries the same ratio in comparison to percutaneous fixation which is about double.

In the Jaura and colleagues study, the average blood loss during surgery in plate group was approximately 600 ml (range, 400–1000 ml) whereas in the pinning group, it was about 100 ml (range, 70–160 ml). In our study, the mean blood loss in the plate group was 413 ml (range, 250–750 ml), which is about fourfold more than the blood loss in the pinning group, which was 86.6 ml (range, 50–150 ml), with a highly significant statistical variance ($P < 0.001$) between the two groups.

4.1. About the complications

Following reconstructive surgery for proximal–humerus fractures, among the most terrifying consequences is AVN of the head of the humerus. For the majority of individuals, AVN results in poorer clinical outcomes and further revision surgeries.[15] Harrison and colleagues stated a very high rate of AVN: of the seven (25%) cases, five of them were four-part fractures, which is possible because of having a great percentage of four-part fractures in his study. Ortmaier and colleagues had two (6%) cases in the percutaneous pinning group and four (13%) cases in the plate group. In the current study, no cases of AVN in either group were encountered throughout the follow-up.

Loss of reduction and malunion are more common with K-wires than with plate fixation resulting usually in varus deformity. In the percutaneous pinning studies: Fenichel and colleagues had seven (14%) cases with substantial secondary displacement because of the inability to fix it by K-wires; three (6%) of them received revision surgeries: in two instances, closed-pinning had to be repeated, and in a single instance, open-reduction and pin fixing was done. Jaura and colleagues had four (13%) cases in the K-wire group and Ortmaier and colleagues had three (10%) cases in the K-wire group who required reosteosynthesis. In our study, we had three (20%) cases of malunion and loss of reduction in the K-wire group: all of them are three part fracture, one of them is diabetic, and all of them are more than 55 years old. In the ORIF studies: Siddalingamurthy and colleagues had four cases of malreduction (16%); Chowdary and colleagues had only one (1.5%) case. In the plate group, we had no cases of malunion (0%).

Infection in percutaneous pinning always occurs as superficial pin tract infection, deep infection is almost not present in the literature in patients treated by percutaneous pinning.

In the Fenichel and colleagues study conducted in Italy, there were five (10%) cases of pin tract infection, which resolved after pin removal. Jaura and colleagues had six (20%) cases of pin tract infection in their K-wire group, who were treated by daily dressings and antibiotics. In our study, pin tract infection occurred in three (20%) cases of the K-wire group, which is comparable to the infection rate in the literature. It was superficially self-limited and resolved by frequent dressings and antibiotics. In the ORIF studies: Chowdary and colleagues had two (2.8%) cases of superficial infection. Jaura and colleagues had four (13%) cases of deep infection in the plate group who were managed by intravenous antibiotics following the culture and sensitivity results had been obtained. Deep infection occurred in our study in two (13%) cases of the plate group, also comparable to the literature. The causative organism in the first of them was *Escherichia coli*, which required specific intravenous antibiotics (Tazobactam, Piperacillin, and Vancomycin) and required a second operative setting for debridement. In the second case, the causative organism was MRSA and the infection had not subsided by intravenous antibiotics or by debridement and necessitated plate removal and fixation by K-wires instead. Union occurred afterward but with marked adhesions and a limited range of motion.

Screw penetration and cutout is a complication mentioned in the literature with plate fixation, which is highly predicted by bone quality in addition to the surgical technique[16]: In the Ortmaier and colleagues study it occurred in five (17%) patients while according to Chowdary and colleagues two (2.8%) cases had this complication. There were no cases of screw cutouts in our study.

Pin perforation occurred in some studies where the wires perforate the head and migrate inside the joint or even to the axilla. Osteoporosis is among the major factors for risk for its incidence.[17] This required retrieval of the wires in two (7.5%) cases in the Jaura and colleagues study and two (4%) cases in Fenichel and colleagues. In the current study, we did not encounter any case of pin perforation.

Stiffness and loss of range of motion occurred in Siddalingamurthy and colleagues, who had six (23%) cases of stiffness; Chowdary and colleagues had two (2.8%) cases. In this study, we had one (6%) case of postoperative stiffness in K-wires, which was a four-part fracture and two (12%) cases in the ORIF group 1 had a deep infection.

4.2. Functional assessment of the results

In the current work, we depend on the Constant–Murley score as the most widely used score in the literature to assess shoulder function.

In the percutaneous pinning studies: in the Fenichel and colleagues study, the mean final Constant score after an average follow-up of 2.5 years (range 1–4 years) was 81 points (range, 60–100). Jaura and colleagues showed a final constant score after 12 months for the K-wire group was 76.4 points (range, 56–100) and Ortmaier and colleagues showed a final Constant score after more than 24 months for the K-wire group of 71.9 points (range, 34–88). In the ORIF studies: Siddalingamurthy and colleagues after 6 months of Constant score was 63.76 points (±10.35 SD). Chowdary and colleagues had the mean Constant score after 15 months was 72 points (±13 SD).

This study has some limitations, which are a small sample size, lacking the long-term follow -up due to time constraints, use of smooth nonthreaded wires due to resource issues, and finally, we could not control every single lifestyle factor and the observational nature of this design leaves the possibility of residual confounding.

4.3. Conclusion

Our conclusion after this study is that proximal–humeral fractures are highly frequent in the elderly, primarily due to osteoporosis. These fractures may be treated with either closed-reduction and percutaneous-pinning or open-reduction and internal fixing with PHILOS plating. PHILOS plate offers precise reductions and prompt mobilization together with an exceptional stable build even in multifractured osteoporotic proximal–humerus fractures. As a successful option for therapy for two- or three-part proximal–humeral fractures, percutaneous K-wire fixing offers less invasiveness, less dissection of the soft tissues, and better scarring. If certain requirements are met, it may serve as a good alternative to open reduction and fixation with plates for managing proximal–humerus fractures: choosing the patient who has a good bone stock not highly osteoporotic. Insertion of the K-wires in a good strong configuration; using thick wires of at least 2.5 mm diameter; having a good purchase in the subchondral bone of the head and supporting the medial calcar humerus. Using small percutaneous portals to reduce fracture fragments under the control of an image intensifier. In cases of difficult unaccepted reduction patient compliance is crucial along with immobilization of his arm until signs of union appear to avoid secondary displacement and malunion.

Authors' contribution

Aly M. El-Geoshy: idea formulation, data collection, analysis, and writing. Ehab K. Gaafar: data collection and writing. Usama G. Abdalla: supervision, writing, and revision.

Conflicts of interest

There are no conflicts of interest.

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