

Original Research Article

Functional outcome following open reduction and internal fixation of proximal humerus fractures with locking compression plate

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ABSTRACT

Background: Proximal humerus fractures (PHFs) are common upper extremity fractures representing break in humerus bone. Incidences of PHFs increased in last few years due to life style changes and increased road accidents. Appropriate management strategy for PHFs is still uncertain. The aim of current study is to assess the functional outcome following open reduction and internal fixation of proximal humerus fractures using locking compression plates.

Methods: Current study is a descriptive investigation conducted on 31 PHFs patients admitted to baby memorial hospital, calicut, between January 2013 to June 2014. Surgical management of PHFs was done by open reduction and internal fixation using locking compression plates and functional outcomes and complications of the employed treatment modality were investigated.

Results: PHFs were observed to be common in 41-60 years age group, with 65% males being affected. Road accidents and domestic falls were observed to be the most common causes of PHFs in younger and elderly populations respectively. Three parts PHFs were observed to be more prevalent, followed by two and four parts fractures. Results of current study revealed that majority of PHFs united by 8-10 weeks duration with 22.58% cases with excellent and 41.93%, 16.12% and 19.35% cases with good, moderate and poor constant and Murley score respectively. Two patients reported post-operative complication of shoulder stiffness, while one patient each reported plate impingement, varus malunion, infection and varus malunion with intraarticular screw cut-out.

Conclusions: Locking compression plates (PHILOS/PHLP) is an efficient treatment modality for proximal humerus fractures allowing early mobilization and good functional outcome.

Keywords: Proximal humerus fractures, Open reduction, Internal fixation, Locking compression plates, PHILOS, PHLP

INTRODUCTION

Glenohumeral joint exhibits series of complex interactions among bone, muscle, and soft tissues making it the most mobile joint in the body.¹ The humerus is the largest, most proximal long bone of the upper extremity.¹ The proximal humerus consists of humeral head the lesser tuberosity, the greater tuberosity, the bicipital groove, and proximal shaft. Proximal humerus develops from three distinct ossification centre including one for the humeral head and

one each from the lesser and greater tuberosities.^{2,3} In the sagittal plane, the humeral head is retroverted 30 degrees relative to the humeral shaft and in coronal plane; it is angled 130 to 150 degrees cephalad relative to diaphysis. In neutral rotation, the greater tuberosity forms the lateral border of the proximal humerus.²⁻⁴ The long head of the biceps passes between the two tuberosities in the intertubercular groove, approximately 1 cm lateral to the midline of the humerus, and its relationship is an important landmark during fracture reduction.¹

Proximal humerus fractures (PHFs) are common upper extremity fractures representing break in the upper bone of arm (humerus).⁵ PHFs represent around 4 to 6% of all fractures and are most commonly observed in osteoporotic elderly populations, older than 50 years.⁵⁻⁸ The incidence peaks in the 60 to 90 years of age with a female to male ratio of 70:30, due to the greater incidence of osteoporosis in females. In majority of cases PHFs occur following a simple ground-level fall on an outstretched arm.^{6,7} PHFs can affect quality of life permanently, due to sequelae.⁹

Recently published reports, estimates the incidence of fall-related proximal humerus fractures to be increased by three fold since 1970.^{5,6} PHFs are classified under a bimodal distribution of age and energy levels, as they can occur due to low energy falls in elderly populations with osteoporotic bone or due to high energy trauma in young individuals.⁹ Evaluation of a proximal humerus fracture begins with thorough assessment of history and series of physical examinations.¹⁰ Baseline level of function, hand dominance, functional demand, and ability to participate in rehabilitation are assessed before making clinical management decisions.⁹ Patients with PHFs commonly present pain and swelling in shoulder with limited range of motion. There may be anterior bulge below the corocoid in cases of anterior dislocation or posterior bulge and anterior sulcus in case of posterior dislocation.^{10,11}

Table 1: Neer and AO classification systems for PHFs.¹⁵

Parameters	
Neer classification	AO classification
Anatomic relationship of 4 segments; (greater tuberosity, lesser tuberosity, articular surface, shaft); two/three or four parts.	Fracture location
Displacement of >1 cm.	Status of the surgical neck
45° angulation.	Presence/absence of dislocation

On palpation there will be tenderness around the shoulder and movements are associated with creptations. Radiography for evaluating trauma series of the shoulder is recommended in three set views, true AP, the lateral or scapular-Y, and axillary views.¹² In addition clinical findings like combined cortical thickness >4 mm, increased lateral plate pullout strength, pseudosubluxation, CT scan and MRI are also used to diagnose PHFs.¹¹⁻¹⁴ Regardless of the imaging investigations, number of displaced fragments should be assessed, to enable appropriate classification of the fracture like Neer or AO classifications (Table 1) for determining efficient management strategy as the management of PHFs depends not only on the type of fracture but also on the functional status and living situation of the patients.¹⁵

Most of the PHFs are nondisplaced or minimally displaced and stable; they can be treated non operatively with early rehabilitation.¹⁶ Sling immobilization followed by gentle progressive rehabilitation is a nonoperative strategy recommended in minimally displaced fractures.¹⁷ Nonoperative management is observed to be successful in the following cases: minimally displaced surgical neck fractures (Neer’s one, two, and three-part), greater tuberosity fracture which is displaced less than 3-5 mm and for patients who are not ideal surgical candidates.¹⁷

Severely displaced and comminuted fractures require surgical management for optimum shoulder function. Different alternatives exists for operative management of PHFs including; closed reduction and percutaneous pinning (CRPP), open reduction and internal fixation (ORIF), intramedullary nailing (IMN), hemiarthroplasty and total shoulder arthroplasty (reverse TSA or standard/anatomic TSA).¹⁶⁻²⁰ A wide variety of treatment modalities used in the past for displaced and comminuted fractures including; tension band wiring, transosseous suture fixation, standard plate and screw fixation, percutaneous wire, screw fixation and hemireplacement arthroplasty work on basic principle of providing stability to fractured part, but majority of these treatment modalities exhibited complications like implant failure, non-union or malunion of fractures, impingement syndrome, and osteonecrosis of humeral head.¹⁸⁻²²

Proximal humerus locking plates are latest generation of anatomically precontoured locking compression plates.²² Precontoured locking plates provides rigid fixation and more angular stability compared to other method of operative treatment and helps in early mobilization and physiotherapy which leads to achieve a painless shoulder with good functional outcome.²³ Conventional implants have higher risk of screw loosening in the humeral head. In locking plates, the screws in the humeral head are locked into the plate and cannot backout or toggle. The plate thus acts as an external fixator put internally. The screws alternatively diverge and converge improving the purchase in the head. The crossed screw increases the pullout strength dramatically. Locking the screw to the plate mechanically recreates a point of cortical bone contact, which may be useful in the cancellous bone of the proximal humerus.²³⁻²⁶ Proximal humerus locking plate (PHLP) and proximal humerus internal locking system (PHILOS) (Figure 1) are anatomically precontoured for the lateral aspect of proximal humerus.²⁷ The plates are low profile for low risk of subacromial impingement and no bending is required. PHLP has 4 proximal locking head screw holes whereas PHILOS plate has 9 proximal locking head screw holes in different orientation to ensure good distribution of forces across the screws.^{27,28}

The proximal locking screws in both PHLP and PHILOS produce an angular stable construct to enhance the grip in osteoporotic bone and multifragment fractures.²⁸ These plates provide adequate stability in weak cancellous bone in humeral head without screw plate compression and

reduce periosteal damage beneath the plate. The plates are very versatile as it has 3 different types of holes; 2 mm suture holes through which sutures passed through rotator cuff are passed and knotted to the plate. These help to maintain reduction and neutralize muscle tension.²⁷⁻²⁹ Locked head screw holes in proximal part in different orientation for angular stability, increasing buttressing and provide high pull out strength.^{27,30,31} LCP combiholes for the choice of two fixation techniques in one implant.

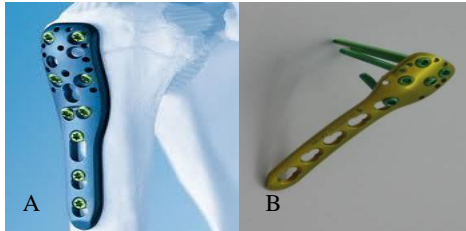


Figure 1: A) PHILOS plate, B) PHLP plate.

Aim of study

Precontoured locking plates provide angular stability with less vascularity disruption and less chances of plate failure and since the treatment goal in PHFs is to achieve a painless shoulder with full functional outcome, so current investigation was executed to assess the functional outcomes following open reduction and internal fixation of proximal humerus fractures using locking compression plate.

METHODS

Study setting

Current study was a descriptive study with follow up element; the study was conducted at department of orthopedics, Baby memorial hospital, Calicut, Kerala, from January 2013 to June 2014.

Selection criteria and sample size

Criteria for inclusion in current study were; patients in the age group of 20-80 years and patients with NEER two part/three parts or four parts fracture. Criteria for exclusion from current study were; patients with one-part fracture, stable two parts fracture, head splitting fractures, open fractures, pathological fractures, isolated tuberosity fractures and medically unfit patients. A total of 31 patients fulfilling inclusion criteria were investigated in current study after taking their informed consent.

Procedure

All patients with proximal humerus fractures fulfilling the inclusion criteria were examined upon admission, according to protocol and associated injuries were noted. The patients were then assessed clinically to evaluate their

general condition, vital signs and local injury. Methodical examination was done to rule out fractures at other sites. Local examination of injured shoulder was done to assess swelling, deformity, loss of function and altered attitude and nerve injury if any was noted. Neurologic deficit of axillary nerve was assessed by looking for anaesthetic patch over lateral aspect of shoulder. Radiograph of proximal humerus were taken, limb was immobilized in arm-pouch and fractures were classified according to Neer's classification. The patients were taken for surgery after routine investigations like Hb percent, RBS, blood urea, serum creatinine, HIV, HbsAg, HCV, ECG and chest X-ray to confirm fitness of patients for surgery. Limb was shaved from shoulder to elbow including axilla just before the surgery. All patients received a prophylactic dose of 1.5 gm of cefuroxime intravenously preoperatively. Patients were anesthetized with general anesthesia or brachial plexus block were used and the operation was done in supine position placing small sand bag under the shoulder. Through delto-pectoral approach, the fracture was exposed and reduced with minimal soft tissue dissection. The anatomical relationship between humeral head and greater tuberosity was reduced and fixed temporarily with K wires. In case of obvious rotation or displacement of the humeral head, a joystick technique was used. The shaft fragment was reduced by abduction, traction and rotation of the arm and reduction was checked under image intensifier.

Definitive fixation with locking plate was done with the plate positioned 10 mm dorsal to the posterior border of the inter tubercular sulcus. PHILOS was placed 8 mm distal to proximal end of greater tuberosity, PHLP was placed 5 mm distal to proximal end of greater tuberosity.²⁷⁻³¹ The aiming device or guiding block provided with the implant aided easy and accurate mounting of LCP drill guide to drill bits in the proximal part of plate and guided the screw during insertion. The inferior screws supporting the humeral head were considered critical and the screws were chosen according to preoperative planning, all the four head screws were inserted to the head fragment. Proximal locking screws were inserted to hold the humeral head and were placed in a unicortical fashion through an external guide and confirmed to be within the humeral head with intraoperative fluoroscopy. AP (internal and external rotation) views and axillary views (90 degrees to each other) were used to visualize screw placement. The distal shaft screws were placed bicortically and a minimum of three bicortical screws were used. Fluoroscopic images were taken to confirm satisfactory fracture reduction, plate positioning and proper length of screws in the humeral head. In case of severe comminution or instability, the rotator cuff, the greater tuberosity, and the lesser tuberosity were fastened to the plate using non-absorbable sutures. Range of motion of shoulder was checked on the table for impingement and wound was closed in two layers after achieving hemostasis.

Appropriate antibiotics and analgesics were given post-operation to patients and all patients arm was immobilized with the aid of arm pouch. Immediate post-operative radiographs were taken to determine the bone alignment and maintenance of reduction. Sutures were removed at the 10th post-operative day. For rehabilitation pendulum exercises were recommended immediately depending on pain and passive range of motion were recommended after first post-operative week. Active range of motion was started after 2-4 weeks depending on stability of osteosynthesis and bone quality. At 4th to 6th post-operative week, immobilization was discontinued and active assisted movements were started up to 90-degree abduction and no forced external rotation. At 6th to 8th post-operative week, full ranges of movements with active

exercises were started. Follow ups were done at 6 weeks, 3 months, 6 months and one year and functional outcome was evaluated using Constant and Murley scoring in which strength measurement was done using a spring balance attached on the forearm distally (Table 2). Strength was measured after 90-degree elevation of arm in the plane of scapula, if pain was involved or if patient was unable to achieve 90 degrees of elevation in the scapula plane the patient was given 0 points. The average strength score was noted in pound (lb). Patients with shoulder stiffness were given physiotherapy for 1-2 weeks on outpatient basis. The patients were examined clinically and radiologically, for range of motion, bone union and complications if any during follow up period.

Table 2: Constant and Murley scoring system.¹⁵

Category	Score
Pain (15 Points)	
No pain	15
Mild	10
Moderate	5
Severe	0
Activity of daily living (20 points)	
Sleep affected	
Yes	0
Sometimes	1
No	2
Recreation/sport limitation	
Severe	0
Moderate	2
No	4
Daily living limitation	
Severe	0
Moderate	2
No	4
Arm positioning	
Up to waist	2
Up to xiphoid	4
Up to neck	6
Up to top of head	8
Above head	10
Range of motion (degree)	
Forward elevation (40 points)	
0-30	0
31-60	2
61-90	4
91-120	6
121-150	8
151-180	10
Lateral elevation	
0-30 degree	0
31-60	2
61-90	4
91-120	6
121-150	8
151-180	10

Continued.

Category	Score
External rotation (hand is not allowed to touch the head)	
Hand behind head with elbow held forward	2
Hand behind head with elbow held back	2
Hand on top of head with elbow held forward	2
Hand on top of head with elbow held back	2
Full elevation from on top of head	2
Internal rotation	
Dorsum of hand to lateral thigh area	0
Dorsum of hand to buttock	2
Dorsum of hand to lumbosacral junction	4
Dorsum of hand to waist (3 rd lumbar vertebra)	6
Dorsum of hand to 12 th dorsal vertebra	8
Dorsum of hand to interscapular region (DV 7)	10
Strength	25

Statistical analysis

The data obtained was coded and entered into Microsoft excel spread sheet and master chart was prepared. Data analysis was done using statistical package for social sciences (SPSS) version 16.0. Descriptive and inferential statistical analysis was done using relevant statistical test. p<0.05 at 95% confidence interval was considered as statistically significant.

RESULTS

In current study 31 cases of PHFs admitted at Baby memorial hospital, Calicut, from January 2013 to June 2014 were investigated. Locking compression plate (PHILOS/PHLP) was used as treatment modality and postoperatively patients were followed up periodically for 1 year. The age of the patients ranged from 21 to 75 years with the mean age of 53.48 years. Out of thirty-one patients, 23 (74.1%) were of less than 65 years of age and 8 (25.8%) were older than 65 years, it was thus observed during current study that proximal humerus fractures were observed more in younger population with good bone stock following high energy trauma and less due to low energy trauma in elderly population. Maximum numbers of patients were observed to be in the age group of 41 to 60 years. Out of 31, 20 (65%) patients were males; even though the occurrence of fracture was observed to be more among men due to higher involvement in day to day activities compared to females, the difference was not statistically significant (Chi square=2.6, p<0.05) (Table 3).

Out of 31 patients, 15 (48.38%) were reported to be injured due to fall on outstretched hand, 14 (45.16%) were injured in road traffic accidents and 2 (6.45%) patients were injured due to fall from height (Table 4). Right side fracture was observed in 58.06% of patients and left side fracture in 42% of patients, however the difference was not found to be statistically significant (Chi square=0.8, p<0.05). There were 9 (29%) patients who had sustained two parts fracture, 15 (48%) patients exhibited three parts

fracture and 7 (22%) patients had four parts fracture (Table 3).

Table 3: Distribution of patients based on varied parameters.

Parameter	N	Percentage
Age groups (in years)		
20-40	8	25.9
41-60	14	45.1
61-80	9	29.0
Sex		
Males	20	65
Females	11	35
Side involvement		
Right	18	58.06
Left	13	41.93
Fracture type		
Two part	9	29
Three part	15	48
Four part	7	22
Duration since the date of injury to surgery (days)		
1-3	25	80.64
4-6	4	12.90
7-10	2	6.4

Table 4: Distribution of patients according to age and mechanism of injury.

Mechanism of injury	<65 years	≥ 65 years	N (%)
Fall on outstretched hand	8	7	15 (48.38)
Road traffic accident	13	1	14 (45.16)
Fall from height	2	0	2 (6.45)
Total, N (%)	23 (74.1)	8 (25.8)	31 (100)

Table 5: Distribution of patients based on variable parameters at one year follow up post treatment.

Parameters	N	Percentage
Pain		
No pain	25	80.64
Mild	6	19.35
Moderate	0	0
Severe	0	0
Daily living activity score		
<5	0	0
6-10	1	3.22
11-15	8	25.80
16-20	22	70.96
Range of forward flexion (degree)		
<60	0	0
61-90	2	6.45
91-120	4	12.90
121-150	16	51.61
151-180	9	29.03
Range of abduction (degree)		
<60	0	0
61-90	2	6.45
91-120	4	12.90
121-150	17	54.83
151-180	8	25.80
Range of external rotation (degree)		
<30	2	6.45
31-60	9	29.03
61-90	20	64.51
Range of internal rotation (degree)		
<30	2	6.46
31-60	11	35.48
61-90	18	58.06
Strength points		
0	4	12.90
5	8	25.80
10	5	16.12
15	8	25.80
20	6	19.35
25	0	0
Constant score		
86-100 (excellent)	7	22.58
85-71 (good)	13	41.93
56-70 (moderate)	5	16.12
55-0 (poor)	6	19.35
Complications		
Nil	25	80.64
Varus malunion	1	3.22
Subacromial Plate impingement	1	3.22
Stiffness	2	6.45
Infected implant	1	3.22
Varus malunion with intraarticular screw cut out	1	3.22

Out of 31 patients, 25 reported injury within 1 to 3 days, treatment of such patients initiated early, 4 patients reported injury after 4 to 6 days so treatment of such patients was initiated late and 2 patients exhibited multiple co-morbidities, due to which surgery was delayed for more than 7 days. The mean duration since the date of injury to surgery was 2.87 days with range of duration between 9 hours to 10 days (Table 3).

In post treatment investigations 6 (19.35%) patients reported mild pain, while 25 (80.64%) patients had no pain, results depicted excellent pain relief in majority of patients. Out of 31 patients, 1 (3.22%) patient reported pain score in range between 6-10, 8 (25.80%) patients reported pain score between 11-15 and 22 (70.96%) reported pain score between 16-20. Investigations depicted majority of patients returned to their daily living activities with good functional outcome.

Forward flexion was observed in the range of 151° to 180° in 9 (29.03%) patients, 16 (51.61%) patients exhibited flexion in range of 121° to 150°, 4 (12.90%) patients showed flexion in range of 91° to 120° and 2 (6.45%) patients showed flexion between 61° to 90°, none of the patients had flexion <60°. Total 8 (25.80%) patients showed abduction between 151° to 180°, 17 (54.83%) patients exhibited abduction between 121° to 150°, 4 (12.90%) patients reported abduction in range of 91° to 120° and none of the patients reported abduction <60°. Out of 31, 20 (64.51%) patients showed an external rotation between 61° to 90°, 9 (29.03%) patients reported external rotation between 31° to 60° and 2 (6.45%) patients were observed to have external rotation <30°.

Total 18 (58.06 %) patients exhibited internal rotation between 61° to 90°, 11 (35.48%) patients reported to have an internal rotation between 31° to 60° while only 2 (6.46%) patients were observed to have an internal rotation <30° (Table 5).

Out of 31, 6 (19.35%) patients obtained 20 strength points, 8 (25.80%) patients obtained 15 points, 5 (16.12 %) obtained 10 points, 8 (25.80 %) obtained 5 points and 4 (12.90%) patients obtained zero strength point. Out of 31 patients 1 (3.22%) patient reported to have varus mal union complication, 1 (3.22%) patient had subacromial plate impingement, 2 (6.45%) patients reported stiffness, 1 (3.22%) patient suffered from infected implant which was removed and 1 (3.22%) patient had varus malunion with intra articular screw cut out (Table 5). Results indicated that all range of movements improved with time (Table 6).

The mean±SD Constant and Murley score, six weeks post treatment was 24.58±6.34, after 3 months mean score was 45.41±8.69, after 6 months mean score was observed to be 61.77±12.63 and after 12 months score was 72.19±15.44. In current study 7 patients exhibited excellent results in terms of functional outcome, 13 patients had good functional outcome, 5 patients had moderate functional outcome and 6 patients exhibited poor outcome (Table 7).

Table 6: Average range of movements post follow up.

Movements	Follow up time			
	6 weeks	3 months	6 months	12 months
Forward flexion	62.36 °	102.09 °	125.45 °	145.80 °
Abduction	58.45 °	103.70 °	120.67 °	143.38 °
Internal rotation	36.63 °	52.23 °	62.35 °	69.25 °
External rotation	27.45 °	42.31°	56.25 °	63.74°

Table 7: Average constant and Murley score post follow up.

Follow up time	Average constant and Murley score	Range of score
6 weeks	24.58	8-36
3 months	45.41	30-60
6 months	61.77	35-82
12 months	72.19	35-90

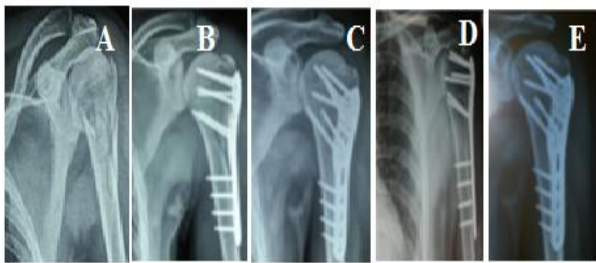


Figure 2: Representative X-ray images of a PHF case study with post treatment functional score of 87, A) three-part fracture, B) immediate post-operative X-ray, C) 6 weeks post-operative image, D) 3 months post-operative image and E) 1-year post-operative image.



Figure 2: Representative images of case study depicting range of movements at post-operative one year follow-up, A) forward flexion, B) abduction, C) external rotation, D) internal rotation and E) strength assessment.

Representative images of a PHF case study with post treatment functional score of 87 is depicted in (Figure 2, 3).

DISCUSSION

The incidence of PHFs is reported to be increased in last few years due to changes in life style and increase in road traffic accidents. Appropriate management strategy for PHFs is still uncertain, most of the PHFs which are undisplaced can be treated conservatively but treatment of displaced fracture or fracture dislocation is difficult, even after thorough analysis and understanding of injury. Several published literature reports that displaced fracture of the proximal humerus have a poor functional prognosis because of severe displacement of fragments.³²⁻³⁴ However, with advantages of anatomically accurate reductions, rapid healing and early restoration of function, open reduction and internal fixation is the preferred modality of treatment in PHFs. The present study was conducted to assess the results of two parts, three parts and four parts PHFs treated through open reduction and internal fixation using locking compression plate. Current study findings were comparable with the various studies conducted in other parts of the world.

PHFs occur more commonly in elderly populations, as per the earlier reports of Fazal et al, Aggarwal et al and Sachde et al, 19-86 years was the most affected age group with the mean age of patients being 56, 58 and 61 respectively. Current study is consistent with these published findings as majority of the patients in current study were from age group of 41-60 years with the mean age of patients being 53.48 years.³⁵⁻³⁷ Reports by Gerber et al, Aggarwal et al and Sachde et al revealed that males were more prone to PHFs as compared to females.³⁶⁻³⁸ Current study also depicted a higher incidence of PHFs in men than in women, probably due to higher involvement of males in day to day activities in comparison to females. Main cause of injury (PHFs) in published reports by Fazal et al, Aggarwal et al, Sachde et al and Gaheer et al was fall on outstretched hand in comparison to road traffic accidents.³⁵⁻³⁷ In Current study findings also, fall on outstretched hand was observed to be the major cause for PHFs. In present investigation, incidence of PHFs was

observed to be significantly more on right hand side (chisquare=0.8, $p<0.05$), the observation was comparable to report of Gerber et al.³⁸ Mostly three parts PHF was majorly observed in the published literature reports by Brunner et al and Gaheer et al and the fractures were treated by open reduction and internal fixation using PHILOS plate, the observations were comparable to current study findings were 15 out of 31 patients were observed to be having three part PHFs and were treated with either PHLP or PHILOS plates.^{39,40} Mostly post-operative complications like infection, malunion, avascular necrosis, impingement, stiffness, screw penetration or screw loosening were reported in the published literature by Brunner et al, Aggarwal et al, Sachde et al and Gaheer et al, current study findings depicted post-operative complications like stiffness and malunion (6.45%), infection, impingement and screw penetration (3.22%).^{36,37,39,40}

The final results of current study were graded according to Constant and Murley scoring criteria. Study findings revealed good to excellent results in 20 (64.51%) patients and moderate result in 5 (16.12%) patients. All the patients were observed to have normal muscle physiology and functional range of motion according to Constant and Murley scoring criteria. Poor result was observed in 6 (19.35%) patients, out of which 1 patient had plate impingement and restriction of abduction; the reason being higher placement of plate, with the tip of the plate almost at the level of greater tuberosity. One patient developed varus malunion. Neck shaft angle $<120^\circ$ was observed in one patient, probably due to comminution of underlying osteoporotic bone which may result in impaction at the fracture site after reduction leading to varus malunion. Two patients reported stiffness with restriction of movements and persistent mild pain, intensive physiotherapy session led to some improvement in one patient out of them, and his Constant score improved to 55 at final follow up. The other patient underwent manipulation of shoulder under anesthesia, which led to some improvement, with final Constant score of 53. One patient was observed to have deep infection that required implant removal and debridement, even though radiograph showed good fracture union, infection was settled in these patients with prolonged antibiotic therapy, a final Constant score of 35 was recorded for this patient during final followup. One patient reported to have varus malunion with intraarticular screw perforation of the humeral head articular surface, this led to persistent stiffness with a constant score of 42, screw removal alternative was offered to the patient, but the patient declined further surgery. Majority of fractures were observed to get united in 8-10 weeks duration with an average of 8.8 weeks, no cases of failure were reported in current study.

Limitations

Limitations of the current study were; the sample size of the investigated study group was small and more concrete

results and recommendations could have been made with a larger sample size. Longer follow up duration could have given a clearer insight to observe the incidence of avascular necrosis which in turn would have aided in establishing more significant correlations between management strategy and its outcomes. Potential difficulty of implant removal is also an unavoidable limitation that needs to be borne by patients of PHFs.

CONCLUSION

It can be concluded from current study findings that with meticulous preoperative surgical planning, good surgical technique, good intraoperative imaging and stable fracture fixation, good to excellent functional outcome can be achieved in PHFs. Current study findings revealed that precise surgical technique, stable fracture fixation, restoration with correct neck shaft angle, minimal dissection, proper placement of plate and judicious use of aiming block with k-wire sleeves for correct placement of locking and nonlocking screws under image intensifier played a crucial role in successful treatment outcome of PHFs. Incorporation of sutures through the rotator cuff into the plate allows the deforming force of the rotator cuff to be counter balanced and neutralized, in current study suturing technique was used especially in four-part fracture for achieving good reduction. It is recommended to pass sutures around the tendon bone interface to provide a bony buttress and prevent the stitches from pulling through soft tissue. Although fixed angle plate is a useful technique, but it is not the sole factor in providing good outcome, basic principles of anatomic reduction, rigid fracture fixation, strong and secure soft tissue repair should also be considered for effective management of PHFs. It was observed that varus malreduction substantially increases the risk of post-operative failure and the mechanical support of the medial region is important for maintenance of reduction. Failure to recreate a medial buttress may lead to early loss of reduction and it was observed that locking screws were unable to support the medial column without anatomic reduction or carefully placement of screws in inferomedial cortex. It was also concluded through current study findings that fixation should be followed by early physiotherapy, the rehabilitation programme plays an important role in functional outcome of surgical management of PHFs. Poor outcome reported in current study were related to severe nature of the associated injuries and gross comminution of the fracture. Thus, it can be overall concluded from current investigation that locking compression plates (PHILOS and PHLP) is an efficient method of osteosynthesis for displaced 2-part fracture, 3-part and 4-part proximal humerus fractures allowing early mobilization and good functional outcome.

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Ethical approval: The study was approved by the institutional ethics committee

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