

ASSESSMENT OF FUNCTIONAL OUTCOME AND POST-OPERATIVE COMPLICATIONS FOLLOWING TREATMENT OF PROXIMAL HUMERUS FRACTURES WITH PHILOS PLATING FIXATION: A RETROSPECTIVE STUDY

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ABSTRACT

Background: Proximal humerus fractures (PHFs) are common, particularly among middle-aged and elderly individuals, and their surgical management remains challenging due to variable fracture patterns, bone quality, and complication risk. The Proximal Humerus Internal Locking System (PHILOS) plate is widely used for fixation, but functional and complication outcomes reported in the literature remain variable and are especially scarce in our study setting and geographical area. **Aim:** To assess the functional outcomes and post-operative complications in patients undergoing treatment of PHFs with PHILOS plate fixation. **Methods:** This is a retrospective study assessed the records of 35 patients with PHFs managed with PHILOS plating fixation. Demographic details, mechanism of injury, and fracture morphology (Neer classification) were recorded. Functional outcome was assessed and graded as excellent, satisfactory, unsatisfactory, or failure, and post-operative complications were documented. **Results:** The mean age of patient was 54.8 ± 15.9 years, with males comprising 60.0% of the cohort. Falls were the predominant mechanism of injury (57.1%), and 2-part fractures were the most common fracture pattern (42.9%). Overall, 77.1% of patients achieved excellent or satisfactory functional outcomes, while 17.1% had unsatisfactory outcomes and 5.7% experienced treatment failure. Functional outcome did not differ significantly according to fracture type ($\chi^2 = 6.840$, $p = 0.336$). Post-operative complications were observed in 17.1% of patients, most commonly stiffness (8.6%), followed by varus malunion (5.7%) and superficial infection (2.9%). Although complications increased with fracture complexity, the association was not statistically significant ($\chi^2 = 7.578$, $p = 0.271$). **Conclusion:** PHILOS fixation is an effective treatment option for PHFs, particularly in achieving satisfactory functional outcomes with a relatively low complication burden.

Keywords: PHFs, PHILOS plating, Functional outcome, Postoperative complications; Neer score

INTRODUCTION

Proximal humerus fractures (PHFs) represent a frequently encountered injury in clinical practice, comprising approximately 4–6% of all fractures in adults and ranking as the third most common fracture among the elderly.^{1,2} PHFs incidences increased alongside population ageing and the growing burden of osteoporosis. In contrast, high-energy trauma continues to account for a substantial proportion of PHFs among younger

individuals.³ In India, PHFs account for approximately 4–7% of fractures in adults and 45–80% of humeral fractures with females affected approximately twice as frequently as males, largely attributable to osteoporosis.⁴ The optimal management of PHFs continues to evolve and remains an area of considerable clinical debate.³ Both conservative and operative approaches have specific benefits and limitations, and the choice between them remains controversial.⁵ The principal objective of treatment is to achieve a pain-free shoulder while restoring the patient's ability to perform routine activities.⁶ Although most PHFs can be treated successfully through non-operative measures, displaced, unstable, and complex fracture patterns may require surgical fixation or arthroplasty to achieve satisfactory outcomes.⁷ Advances in implant design over recent decades, particularly the development of locking plate constructs and intramedullary devices, together with the increasing use of reverse shoulder arthroplasty, have considerably broadened the range of surgical treatment options.³

Several methods of internal fixation have been described for the treatment of PHFs, including K-wire fixation, screw fixation, blade plates, external fixation, T-plates, intramedullary implants, locking compression plates, and shoulder arthroplasty. However, none of these techniques has consistently produced uniformly favorable outcomes across different fracture patterns. Effective treatment depends on achieving appropriate anatomical alignment, providing sufficient mechanical stability, and facilitating early postoperative mobilization, all of which are essential for restoration of shoulder function.⁸

The blood supply of the humeral head may be compromised by the fracture itself and can be further affected by soft-tissue disruption during open reduction and internal fixation. Surgical treatment has consequently been associated with complications including malunion, nonunion, and avascular necrosis. Prolonged surgical exposure and inaccurate positioning of implants may further increase the likelihood of avascular necrosis. Accordingly, techniques that limit soft-tissue stripping and minimize unnecessary surgical dissection are advocated to reduce vascular compromise and related complications.⁷ At the same time, adequate stability is essential for fracture healing and for permitting early restoration of shoulder movement. Consequently, several fixation modalities, including screws, AO T-plates, locking compression plates, and osseous suturing techniques, have been employed in the management of PHFs.⁸

The Proximal Humerus Internal Locking System (PHILOS) plate was introduced to address several of the challenges associated with fixation of proximal humeral fractures. Its locking screws provide angular stability, while the design permits fixation of the tuberosities through dedicated suture holes and aims to limit soft-tissue disruption. These features facilitate stable fracture fixation and allow early postoperative mobilization, which is important for achieving favorable functional recovery.^{9,10} Nevertheless, reported outcomes following PHILOS plating have varied according to fracture characteristics, bone quality, and the experience and technical expertise of the surgeon.^{11,12}

Furthermore, evidence describing functional outcomes and postoperative complications following PHILOS plate fixation of PHFs remains limited in our study setting and geographical region. Therefore, the current study was designed with the main purpose of assessing functional outcomes and postoperative complications among patients with PHFs treated using the PHILOS plate fixation technique.

METHODOLOGY

Study design

This is a retrospective study assessed the medical records of 35 patients with PHFs managed with PHILOS plating fixation.

Inclusion criteria

1. Age: >18 years
2. Displaced 2-, 3-, and 4-part PHFs
3. Underwent surgical management with a PHILOS plating fixation

Exclusion criteria

1. Open fractures
2. Undisplaced fractures
3. Isolated tuberosity fractures
4. Associated neurovascular injury
5. Severe medical comorbidities

Data collection and Assessment parameters

The socio-demographic details of patients such as age, gender, residence geographic area, and socio-economic status (SES) were recorded in a structured proforma. The baseline characteristics such as side affected, mode of

injury and type of fracture were recorded and assessed.

Patients were followed systematically at 2, 6, 12, and 24 weeks after surgery. Fracture healing and postoperative complications were assessed using standard anteroposterior and Y-view radiographs of the shoulder joint. Functional outcomes were evaluated at the 24-week follow-up using the NEER scoring system.¹³ Based on the obtained scores, patients were categorized as having excellent (90–100), satisfactory (80–89), unsatisfactory (70–79), or failed (<70) outcomes.¹⁴

Postoperative rehabilitation was implemented according to a standardized institutional protocol. Pendulum exercises were initiated immediately after surgery, depending on the patient's pain tolerance. Passive range-of-motion exercises commenced during the first postoperative week, whereas active range-of-motion exercises were introduced between the second and fourth weeks, depending on fracture stability and bone quality. Active-assisted movements were encouraged with abduction restricted to 90 degrees and without forced external rotation. Thereafter, active exercises involving a full range of shoulder movements were initiated between the sixth and eighth postoperative weeks.

STATISTICAL ANALYSIS

Data were entered in Microsoft Excel 2021 and statistical analysis was done using IBM Statistical Software for Social Sciences (SPSS) version 23. Categorical variables were represented in the form of frequencies and percentages. Continuous variables were presented as descriptive statistics such as mean and standard deviation (SD). Categorical variables were analysed using the Chi-square test. $p \leq 0.05$ was considered statistically significant.

RESULTS

The study population had a mean age of 54.8 years, with the largest proportion aged 61–70 years (28.6%) followed by 51–60 years (20.0%) and 41–50 years (17.1%). Males predominated (60.0%) compared with females (40.0%). Most participants were from urban areas (57.1%), while 42.9% were from rural areas. Regarding socioeconomic status (SES), lower-middle SES was the most frequent category (34.3%) followed by upper-lower (28.6%) and upper-middle (20.0%) (Table 1).

Table 1. Demographic characteristics

Variables	N (%)
Age (Years)	
21 - 30	3 (8.6)
31 - 40	4 (11.4)
41 - 50	6 (17.1)
51 - 60	7 (20.0)
61 - 70	10 (28.6)
>70	5 (14.3)
Mean $\pm$ SD	54.8 $\pm$ 15.9
Gender	
Female	14 (40.0)
Male	21 (60.0)
Residence	
Rural	15 (42.9)
Urban	20 (57.1)
Socio-economic status (SES)	
Lower	4 (11.4)
Lower middle	12 (34.3)
Upper	2 (5.7)
Upper lower	10 (28.6)
Upper middle	7 (20.0)

Values were N (%) unless otherwise stated

The right side was slightly more frequently affected (54.3%) than the left (45.7%). Falls were the predominant mechanism of injury, accounting for 57.1% of cases, while road traffic accidents (RTAs) contributed 42.9%. Regarding fracture morphology, 2-part fractures were most common (42.9%), followed by 3-part fractures (37.1%) and 4-part fractures (20.0%) (Table 2).

Table 2. Baseline characteristics

Variables	N (%)
Side affected	
Right	19 (54.3)
Left	16 (45.7)
Mode of injury	
Fall	20 (57.1)
Road traffic accidents (RTA)	15 (42.9)
Fracture type	
2 Part (NEER type 2)	15 (42.9)
3 Part (NEER type 3)	13 (37.1)
4 Part (NEER type 4)	7 (20.0)

Values were N (%) unless otherwise stated

The results on distribution of patients based on mode of injury and type of fracture were represented in Table 3. Results depicted that distribution of fracture patterns was broadly comparable across the two injury mechanisms. Among patients with 2-part fractures, 40.0% were associated with falls and 46.7% with RTAs. Similarly, 3-part fractures accounted for 40.0% of fall-related and 33.3% of RTA related injuries. Whereas 4-part fractures represented 20.0% of cases in both groups. Overall, 2-part fractures were the most frequent pattern (42.9%), followed by 3-part (37.1%) and 4-part fractures (20.0%).

Table 3. Patient distribution based on mode of injury and type of fracture

Type of fracture		Mode of injury		Total
		Fall	RTA	
2 Part (NEER type 2)	Count	8	7	15
	%	40.0%	46.7%	42.9%
3 Part (NEER type 3)	Count	8	5	13
	%	40.0%	33.3%	37.1%
4 Part (NEER type 4)	Count	4	3	7
	%	20.0%	20.0%	20.0%

The functional outcomes were generally favorable, with 77.1% of patients achieving excellent or satisfactory outcomes. Specifically, 37.1% had excellent outcomes and 40.0% had satisfactory outcomes, while 17.1% had unsatisfactory outcomes and 5.7% experienced treatment failure. Overall, the findings indicate that the majority of patients achieved clinically favorable functional recovery following treatment of PHFs with PHILOS plating (Figure 1).

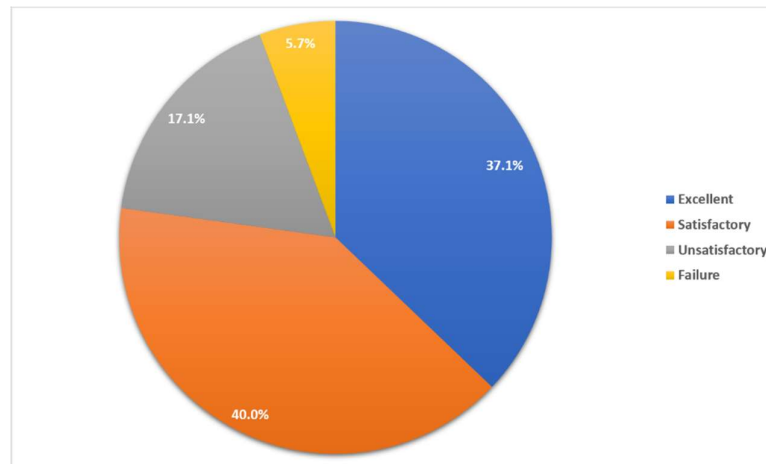


Figure 1. Functional outcomes

Functional outcomes varied across fracture types, with excellent outcomes most frequent among 2-part fractures (46.7%), whereas satisfactory outcomes predominated among 3-part fractures (61.5%). However, the association between fracture type and functional outcome was not statistically significant ($\chi^2 = 6.840$, $p = 0.336$), indicating that fracture classification was not significantly associated with functional outcome in study cohort (Table 4).

Table 4. Association between fracture type and functional outcomes

		Fracture type			Total
		2 Part (NEER type 2)	3 Part (NEER type 3)	4 Part (NEER type 4)	
Excellent	Count	7	4	2	13
	%	46.7%	30.8%	28.6%	37.1%
Failure	Count	1	0	1	2
	%	6.7%	0.0%	14.3%	5.7%
Satisfactory	Count	3	8	3	14
	%	20.0%	61.5%	42.9%	40.0%
Unsatisfactory	Count	4	1	1	6
	%	26.7%	7.7%	14.3%	17.1%
$X^2 = 6.840$					
$P = 0.336$					

Post-operative complications were uncommon, with 82.9% of patients experiencing no complications. The most frequent complication was post-operative stiffness (8.6%), followed by varus malunion (5.7%) and superficial infection (2.9%). Overall, the findings indicate a low post-operative complication burden, with stiffness representing the predominant adverse outcome (Figure 2).

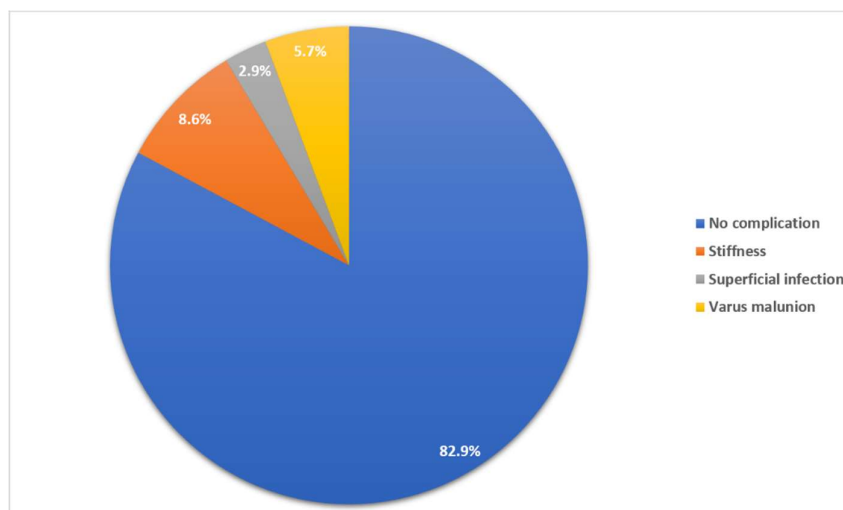


Figure 2. Post-operative complications

The results on association between fracture type and post-operative complications were represented in Table 5. The proportion of patients without post-operative complications decreased with increasing fracture complexity from 93.3% in 2-part fractures to 76.9% in 3-part and 71.4% in 4-part fractures following treatment of PHFs with PHILOS plating fixation technique. Stiffness was most frequent among 3-part fractures (15.4%), while superficial infection and varus malunion occurred only among 4-part fractures (14.3% each). However, the association between fracture type and post-operative complications was not statistically significant ($\chi^2 = 7.578$, $p = 0.271$).

Table 5. Association between fracture type and post-operative complications

		Fracture type			Total
		2 Part (NEER type 2)	3 Part (NEER type 3)	4 Part (NEER type 4)	
No complication	Count	14	10	5	29
	%	93.3%	76.9%	71.4%	82.9%
Stiffness	Count	1	2	0	3
	%	6.7%	15.4%	0.0%	8.6%
Superficial infection	Count	0	0	1	1
	%	0.0%	0.0%	14.3%	2.9%
Varus malunion	Count	0	1	1	2
	%	0.0%	7.7%	14.3%	5.7%
$\chi^2 = 7.578$					
$P = 0.271$					

DISCUSSION

In this retrospective study, patients treated with PHILOS plating had a mean age of 54.8 years, with the highest proportion of cases occurring during the sixth and seventh decades of life. Males constituted the majority of the study population (60%). A comparable demographic profile has been described in several recent Indian studies. George et al., reported a mean patient age of 52.3 years, a male-to-female ratio of 2.5:1, and right-sided involvement in 62.9% of cases.¹⁵ Similarly, Jhamnani et al., observed a mean age of 54.5 years and a marked male predominance of 78.1%.¹⁶ Pradeep et al., reported a mean age of 53.2 years, with males comprising 60% of their cohort and right-sided fractures occurring in 62.5% of patients. These findings are broadly comparable with the present study, in which 54.3% of fractures involved the right side.¹⁷ However, this relatively younger and male-dominated patient profile differs from the conventional epidemiological pattern of PHFs, which predominantly affects elderly women with osteoporosis. Agrawal et al., likewise reported a comparatively younger cohort, with a mean age of 47 years.¹⁴ Such differences may be attributable to regional referral characteristics and the contribution of high-energy trauma among individuals of working age treated at tertiary-care centres, rather than indicating a fundamental alteration in the established epidemiology of PHFs.

The injury mechanisms observed in the present study were also consistent with this demographic distribution. Falls represented the leading cause of injury (57.1%), while road traffic accidents (RTAs) accounted for the remaining 42.9%. George et al., reported a similar pattern, with falls and RTAs accounting for 45.7% and 48.6%

of injuries, respectively. Agrawal et al., also demonstrated a nearly balanced distribution between falls (45.5%) and RTAs (54.5%).¹⁴ Jhamnani et al., however, documented a somewhat greater contribution from RTAs (56.3%) than falls (43.8%).¹⁶ In terms of fracture configuration, 2-part fractures were most frequent in the current series (42.9%), followed by 3-part (37.1%) and 4-part fractures (20.0%). This distribution was broadly similar to that reported by Jhamnani et al., who observed 2-part, 3-part, and 4-part fractures in 46.9%, 37.5%, and 9.4% of patients respectively.¹⁶ The relatively comparable distribution of fracture patterns across fall- and RTA-related injuries in the present cohort suggests that the mechanism of injury alone did not demonstrate a clear relationship with fracture complexity.

Overall functional recovery following PHILOS fixation was favourable. More than three-quarters of the patients (77.1%) achieved either excellent or satisfactory functional outcomes, comprising 37.1% with excellent and 40.0% with satisfactory results, whereas treatment failure was observed in only 5.7%. These findings are generally comparable with previously published evidence regarding PHILOS fixation. Using the Neer scoring system, Agrawal et al. reported 39% excellent, 27% satisfactory, 21% unsatisfactory, and 12.1% failed outcomes, demonstrating a broadly comparable pattern of functional recovery.¹⁴ Jhamnani et al., reported a mean Constant-Murley score of 85.8, with excellent functional recovery particularly evident among patients with 2-part fractures.¹⁶ Pradeep et al., reported a mean Constant-Murley score of 80.7 at six months and found that 87.5% of patients achieved shoulder abduction exceeding 90°. In the present study, excellent outcomes were most frequently observed in 2-part fractures, whereas satisfactory outcomes were predominant among 3-part fractures. Nevertheless, fracture type was not significantly associated with functional outcome ($\chi^2 = 6.840$, $p = 0.336$). A similar observation was reported by Jhamnani et al., in which favourable outcomes were achieved across both 2- and 3-part fracture groups.¹⁶ These findings indicate that fracture morphology alone may not determine final shoulder function; factors such as the adequacy of reduction, restoration of medial calcar support, and technical aspects of fixation may have an important influence on functional recovery.

It was understood from the literature that the favourable functional results associated with PHILOS plating can be attributed, at least in part, to the biomechanical characteristics of its locking construct. The angular-stable configuration allows multiple divergent locking screws to engage with the plate, providing resistance against varus collapse and screw cut-out, including in osteoporotic bone.¹⁸ In addition, the low-profile, precontoured design facilitates relatively less invasive fixation, potentially reducing periosteal stripping and helping to preserve the vascular supply of the humeral head, thereby limiting the risk of avascular necrosis.¹⁹ The stability provided by this construct also facilitates earlier postoperative mobilization and may consequently reduce the risk of shoulder stiffness.¹⁵ However, the rigidity of the construct may result in greater stress concentration at the bone-screw interface. Inadequate restoration of medial calcar support may therefore increase the possibility of screw penetration and related fixation failure.¹⁸

The safety profile observed in the present cohort was favourable, with 82.9% of patients remaining free from postoperative complications. The principal complications were postoperative stiffness (8.6%), varus malunion (5.7%), and superficial infection (2.9%). These findings compare favorably with the complication estimates reported by Oldrini et al., in a systematic review and meta-analysis involving 4,200 patients across 76 studies. Their pooled overall complication rate was 23.8%, with screw cut-out (4.1%), avascular necrosis (3.1%), and subacromial impingement (1.5%) representing the most frequently reported complications; notably, the complication rate increased to 29.5% among patients older than 55 years.²⁰ In a comparative study evaluating ALPS and PHILOS plates, Chen et al., reported a significantly greater overall complication rate with PHILOS fixation than with the newer implant system.²¹ Conversely, George et al. observed complications in only two of 35 patients, consisting of implant failure and varus collapse, which is broadly consistent with the low complication burden observed in the present series.¹⁵ The relatively low complication rate in the current study may be related to careful restoration of the neck-shaft angle and appropriate positioning of medial calcar screws during fixation. These technical considerations have been repeatedly recognised as important factors in reducing the risk of varus collapse and screw perforation.

Analysis according to fracture complexity showed a progressive reduction in the proportion of patients without complications as fracture severity increased. A complication-free course was observed in 93.3% of patients with 2-part fractures, compared with 76.9% of those with 3-part fractures and 71.4% of those with 4-part fractures. Despite this apparent gradient, the association was not statistically significant ($\chi^2 = 7.578$, $p = 0.271$). The direction of this relationship is nevertheless consistent with findings from previous studies. Oldrini et al., demonstrated that increasing patient age and fracture severity were associated with greater complication rates,²⁰ while Agrawal et al., also observed a higher complication burden among patients with more comminuted fracture patterns.¹⁴

The present retrospective study has several strengths. It provides an integrated assessment of patient demographics, mechanism of injury, fracture morphology, functional recovery, and postoperative complications within a single cohort, thereby permitting assessment of relationships between these clinical variables. Nevertheless, important limitations should be considered when interpreting the findings. The retrospective and single-centre nature of the study introduces the possibility of selection and information bias. Furthermore, the relatively small sample size may have reduced statistical power for subgroup comparisons, particularly in the 4-

part fracture group. The lack of a control or comparator group also prevents direct assessment of the relative efficacy of PHILOS fixation against alternative treatment strategies. In addition, the follow-up period may not have been sufficiently long to identify delayed complications, including avascular necrosis and secondary osteoarthritis. Larger prospective multicentre investigations with extended follow-up are therefore required to confirm these observations and to further clarify the influence of fracture complexity on functional recovery and postoperative complications following PHILOS plating.

CONCLUSION

In conclusion, PHILOS plating for proximal humerus fractures were associated with favorable functional recovery in study cohort, with more than three-quarters of patients achieving excellent or satisfactory outcomes. Post-operative complications were relatively infrequent, with stiffness being the most common adverse event. Although functional outcomes and complications showed a tendency to vary with increasing fracture complexity, neither association reached statistical significance. These findings support PHILOS fixation as an effective treatment option for proximal humerus fractures, particularly in achieving satisfactory functional outcomes with a relatively low complication burden.

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