Journal of Rare Cardiovascular Diseases
ISSN: 2299-3711 (Print) | e-ISSN: 2300-5505 (Online)
www.jrcd.eu
RESEARCH ARTICLE

FUNCTIONAL OUTCOMES OF PROXIMAL HUMERAL FRACTURES MANAGED WITH PHILOS PLATE FIXATION TECHNIQUE IN A TERTIARY CARE HOSPITAL IN INDIA: A PROSPECTIVE STUDY

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Article History
Received: 16.09.2025
Revised: 29.09.2025
Accepted: 07.10.2025
Published: 28.10.2025

Abstract: ***Background:***Proximal humeral fractures (PHF) are a common orthopaedic problem (4-5% of all fractures), particularly among elderly persons. Displaced comminated PHF often require surgical treatment so as to ensure thorough anatomical position, angular stability, and early mobilization for better functional outcomes. This study investigates the functional and radiological outcomes of surgical treatment Proximal humerus internal locking system for patients with these PHF.***Method:*** A prospective study was carried out on 20 patients with proximal humeral fractures, with 50% being diagnosed as three-part fractures according to Neer's classification. This study used Constant-Murley score to assess functional outcome, and radiographic examinations were performed after PHILOS plate surgical fixation.***Results***: The average age of participants was 47.8 years, with male patients comprising 75%. Significant improvements in forward flexion scores have been observed, indicating improved recovery and function. Approximately 75% of patients had no complications following surgery, with just one incidence of malunion (5%), and four occurrences of shoulder discomfort (20%). The entire mean Constant-Murley score was considerably in acceptable range (55% in 81-90 range), indicating beneficial functional restoration.***Conclusion:*** PHILOS plate fixation effectively addresses proximal humeral fractures, with positive outcomes, particularly in younger patients, including better forward flexion scores and minimal complication rates. Further research with more patient size is required to validate these results.

Keywords: Proximal humeral fractures, Neer's classification, PHILOS plates, forward flexion, Constant-Murley score.

INTRODUCTION

Proximal humerus fractures (PHF) account for 4-5% of all fractures and 45% of all humeral fractures, with an increased incidence in elder patients (more than 50 yrs) due to osteoporosis and age-related degeneration of the bones. Fractures involving the humeral head, greater and lesser tuberosity, as well as proximal shaft become more common above the age of 40, accounting for up to 76% of cases in this age group(Lind et al., 1989). While adolescents may experience such injuries from high-energy trauma, older adults are more likely to sustain them from low-energy mechanisms, which pose major issues due to poor bone quality and deforming muscle stresses (Court-Brown & McQueen, 2007; Neer, 2006).
Early detection and adequate therapy are critical, as non-operative treatment, traditionally thought to be acceptable for two-, three-, and four-part fractures in senior individuals, has been linked to prolonged pain, stiffness, and functional impairment (Kannus et al., 2000; Paavolainen et al., 1983). The diagnosis of PHF can been easily made by a 3-right angled trauma series X-ray, supported with CT or MRI, and standardized by Neer's 4-part classification system (Court-Brown & McQueen, 2007; Neer, 2006). This approach enables more accurate diagnosis, standardized management, and better comparison of long-term outcomes (Konrads et al., 2023; Lenza & Faloppa, 2015).

Most non-operative remedies for proximal humeral fractures result in satisfactory functional outcomes in 80–85% of cases. But if left untreated without surgery, 15–25% of displaced proximal humerus fractures, particularly comminated ones, have poor functional results. In such instances, significant movement generally requires surgical fixation to get better outcomes like rigid anatomical fixation, angular stability, and early mobilization for optimal limb function (Berkes et al., 2014; Bernstein et al., 1996). Percutaneous pinning, intramedullary nails, hemiarthroplasty, osteosynthesis using cancellous screws, and internal fixation with locking plates are common surgical techniques (Gangurde et al., 2013; Mittal & Banerjee, 2012). However, these procedures can result in problems such as implant failure, loss of reduction, non-union, malunion, or impingement syndrome (Lenza & Faloppa, 2015).

Selecting the right approach is critical for reducing problems and ensuring successful results.
For proximal humerus fractures, there are various fixation options, including conventional plates, T-buttress plates, screw fixations, k-wires, locking plates, and prosthetic replacements (Pawaskar et al., 2012).

Although locking plates have improved clinical outcomes and improved standards for internal fixation, yet is still a high risk of failures and problems. Every fixation technique has its own unique challenges (Gonzalez et al., 2023). Specifically, the risk of failure associated with standard plating system fixation is greatly increased when poor cancellous bone quality exists in the proximal humerus, particularly in elderly individuals.

Many surgeons prefer nailing to plating for surgical neck fractures, and locking plates are typically used to treat three- and four-part fractures (Foruria, 2023). Nonetheless, there is ongoing dispute about the best way to manage displaced proximal humerus fractures. However, the emphasis is on safe, basic fracture realignment procedures that restore anatomic stability while also ensuring fracture healing and functional recovery. This highlights the importance of reconsidering treatment approaches in order to enhance outcomes for these patients. Although there are a number of techniques for fixing fractures, plating is still the most widely used osteosynthesis technique. Proximal humerus internal locking system (PHILOS) plates have been used to minimize these problems, particularly in older osteoporotic patients.

This innovative plating method is made to accommodate the intricate proximal humeral anatomy while offering stable attachment. Patients with osteoporotic bone, when conventional fixation techniques might not work, benefit most from it. By using locking screws to provide angular stability, the PHILOS plate increases fixation strength and lowers the possibility of issues (Dussa1 et al., 2016). This plate reduces the likelihood of implant failure and non-union by offering greater stability than conventional plating techniques, especially in osteoporotic bone. Because of this, orthopedic surgeons now prefer it for treating different kinds of proximal humeral fractures.

Despite PHILOS plates have been used extensively for proximal humerus fractures, limited studies have thoroughly examined their long-term functional outcomes in elderly osteoporotic patients. Hence, the purpose of this study is to explore the clinical and radiological outcomes of PHF surgery in a tertiary care hospital using PHILOS plate surgical procedure.

MATERIAL AND METHODS:

Study design:

The study was conducted in the department of Orthopaedics, at Aarupadai Veedu Medical College & Hospital, Puducherry, India. It is a hospital based prospective study to assess the clinical and radiological outcome of PHF in patients who underwent surgical proximal humerus interlocking osteosynthesis/PHILOS. All the patients fulfilling the inclusion criteria during the above-mentioned study period was included. Sample size was 20 in number based on the previous year statistics available in medical records department. The Study period was 18 months starting from the date of Institutional ethical committee approval.

Inclusion criteria:

Patients with either Two-part or three-part fracture of proximal humerus.
Adult with >18yrs.
Patients who completely fit for surgery.

Exclusion criteria:

Children & adolescent patients <18yrs.
Patients with acute infections.
Patients medically unfit for surgery.

Ethical consideration:

The study was successfully carried out after obtaining approval from the institutional ethical committee. Separate written informed consents were obtained from all the participants before collecting the data.

Pre-op Assessment

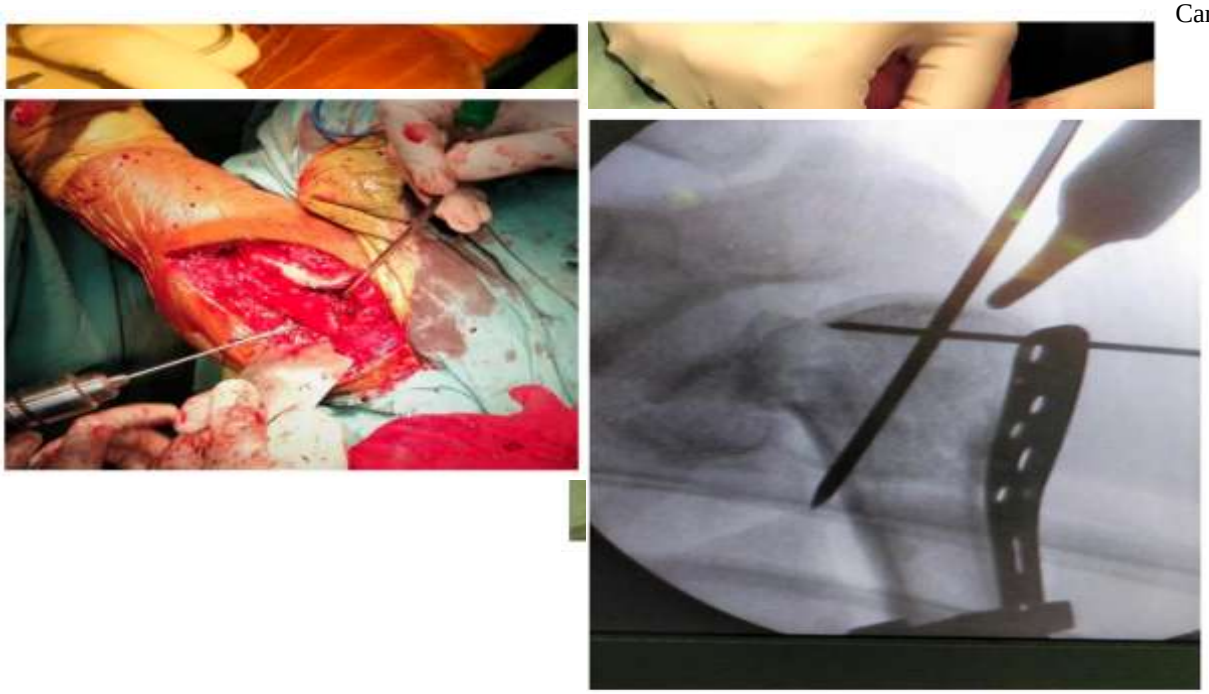
A comprehensive clinical examination and detailed history were performed to rule out related injuries upon initial resuscitation, and the distal neurovascular state was evaluated. Regular investigations were conducted, such as ECG, chest X-ray, and blood testing. Fractures were identified using Neer's and AO classification systems after radiographs of the afflicted shoulder were obtained in Anterior, Posterior, Lateral, and Axillary views. CT images were performed on chosen complicated fractures, and anesthesia fitness was assessed prior to surgery. All patients received 1.5 gram of Laricef (cefoperazone and sulbactum) intravenously thirty minutes prior to surgery. All patients were positioned supine on the table, with a sandbag placed between the spine and the medial border of the scapula to elevate the affected side and facilitate anterior joint access.

Operative Procedure

All twenty patients underwent surgery using the conventional deltopectoral technique. After the skin incision, the muscle, fascia, subcutaneous tissue, and the conjoint tendon was retracted medially. Using image intensifier, 1.5- or 1.8-mm K-

wires have been used to minimize and temporarily fix the fracture fragments. Then the PHILOS plate was placed 8 mm distal to the greater tuberosity, maintaining the long head of the biceps tendon. The humeral head and metaphyseal shaft are fixed with locking screws, and the screw length was established using a measuring equipment (Figure 1).

Figure 1. Showing the operative procedure. (a) Deltopectoral approach, (b) Cephalic vein (c) Fracture reduction and (d) Carm imag



The implant's location and stability were examined using image intensifier investigations and shoulder mobility assessments. A vacuum drain was inserted, and the wound was closed in layers (Doshi, Sharma, Naik, et al., 2017; Saber et al., 2022).

Post-operative period:

On the second post-operative day, the drain was removed. Antibiotics were given intravenously until the third post-operative day. After eleven days of surgery, the sutures were removed out.

Post-op X-rays

Following surgery, X-rays are taken right away to record the alignment, reduction, and fixation of fractures. In order to monitor the fracture union and detect any implant loosening, deviations in screw penetration, screw backout, impingement, or failure, X-rays are then taken every three to four weeks.

Post-op rehabilitation

Phase I exercises, consisting pendulum exercises, commenced in the first week. By the third week, mild passive forward flexion, internal and external rotation exercises has been started. Phase II activities, including active range of motion and resistance workouts, began within 4-6 weeks. Phase III workouts, which included advanced stretching and strengthening exercises, began three months later. Lifting of light weight things began after three months.

Functional and Radiological outcome Assessment:

The Constant-Murley Score was used to assess post-operative functional outcomes. Radiological outcomes were assessed using periodic X-rays during follow-ups, which recorded reduction quality, fracture alignment, articular congruity restoration, fracture union, PHILOS plate deviation, screw penetration, backout, implant loosening, and failure (Hill & Bialocerkowski, 2020).

The Constant-Murley score (CMS) is a 100-point scale consisting of several distinct parameters. Those features indicate the patient's discomfort level as well as his or her capacity to do every-day normal activities. The Constant-Murley score was developed to assess functionality following treatment for a shoulder injury. The test can be divided into four subscales: discomfort (15 points), daily activities (20 points), strength (25 points), and shoulder range of motion (40 points). The higher the score, the better the quality of the function (Fairley et al., 2024).

Statistical analysis:

The results were entered and analysed statistically using EPI INFO software version 7.2.1.0 and software SPSS version 24.0 will be used for analysis. Description of categorical variables were performed using frequency and proportion and continuous variables will in mean and standard deviation. Association of age, type of injury and co-morbidities were compared with outcome of surgery by using chi-square test. All tests will be tailed and p value <0.05 will be considered significant.

RESULTS AND OBSERVATIONS:

Demographic and clinical variables

The study included 20 patients, 5 females and 15 males, ranging in age from 24 to 66 years, with an average of 47.8 years. The majority of patients (35%) were between 41 and 50 years old. Twelve patients had right-hand proximal humerus fractures, while eight had fractures on the left, and were related to right-handedness. In the 20 cases, 14 injuries were caused by indirect accidents, while 6 were caused by direct trauma. Data are shown in table 1.

Neer's classification and O/OTA classification

The fractures in 20 patients were classified using Neer's classification, with 3-part fractures being the most common (50%), followed by 2-part fractures (45%) and 4-part fractures (5%). Patients with Neer's 3-part fractures had a higher Constant score compared to those with 2-part and 4-part fractures (figure 2 b).

The fractures were categorized using the O/OTA system. Type A fractures accounted for 50% of instances (A1: 5%, A2: 20%, A3: 25%), while Type B fractures accounted for 50% (B2: 25%, B3: 20%). Only one (5%) case was classified as Type C3. Data are represented in table 1 and figure 3.

Table 1. Demographic and clinical variables

Variables	Levels	Counts	% of Total
Gender	F	5	25.0 %
	M	15	75.0 %
Age Group	21-30	3	15%
	31-40	3	15%
	41-50	7	35%
	51-60	3	15%
	61-70	3	15%
	71-80	0	0%
	81-90	1	5%
Side	Left	8	40.0 %
	Right	12	60.0 %
Mode Of Injury	Direct	6	30.0 %
	Indirect	14	70.0 %
Neer's Classification	2	9	45.0 %

	3	10	50.0 %
	4	1	5.0 %
AO/OTA Classification	A1	1	5.0 %
	A2	4	20 %
	A3	5	25.0 %
	B2	5	25.0 %
	B3	4	20.0 %
	C3	1	5.0 %

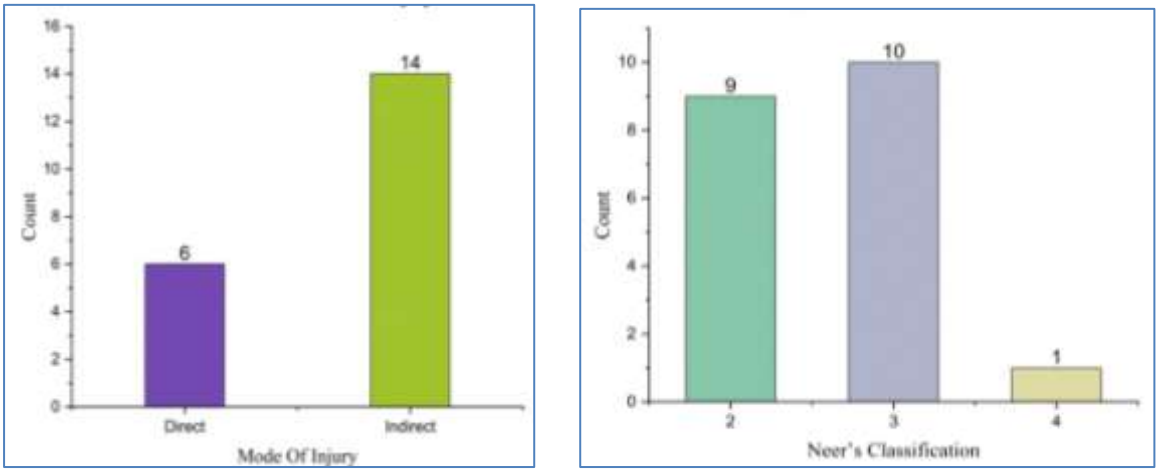


Figure 2. Mode of injury (a) and patient count under Neer's Classification (b)

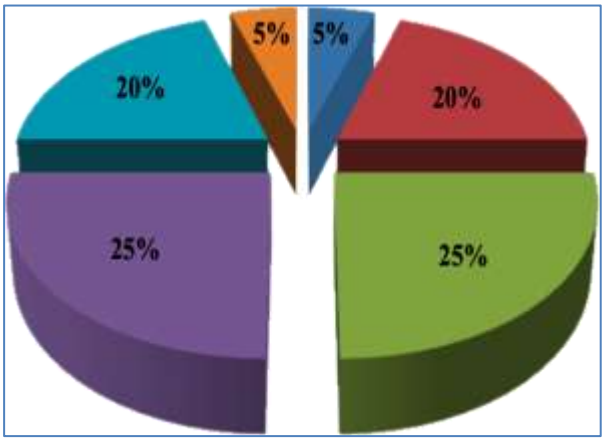


Figure 3. Fracture pattern by AO/OTA classification

Pain score

The study evaluated six functional parameters: Pain Score, ADL Score, Forward Flexion and Abduction Score, Internal and External Rotation score, and Total Score. All twenty patients were evaluated for each parameter, and scores ranged from 0 to the highest values for each parameter. In the current study 19 patients had no pain during union period among

the 20 cases. The average ADL score was 18.5, which indicates good functional capacity, whereas the average pain score was 15, which indicates moderate discomfort.

ADL Score

Atotal of 40% (25% with >18 score) of participants scored in the "Excellent" category, with a notable 30% rated as "Good." Only 5% were rated as "Fair," indicating that the majority of individuals show a positive level of activity living, with more than half achieving a score above 18. Results are depicted in figure 4(a).

Flexion and Abduction score

As shown in figure 4(b), the Forward Flexion Selection Score shows that nearly all of assessments (75%) fall into Category A, indicating a high level of forward flexion. However, only 5% of the evaluations fall into Category C, indicating minimal forward flexion (Figure 4b). Regression analysis shown significant co-relation (p=0.01 in B-A and p<0.001in C-A) with total score.

When examining the active range of motion, we found that the internal rotation reached L1 (range: gluteus to T7), the external rotation was 36° (range: -5° to 60°), and the average anterior flexion was 104° (range: 20° to 160°). The Forward Flexion Selection Score showed 15 excellent, 4 good, with one poor result. In abduction, we found 4 patients got excellent results,

14 good and 2 poor in abduction selection score (Figure 4c).

External and internal rotation score

Of the participants, 40% obtained a score of "Excellent," while a remarkable 55% received a score of "Good." With only one patient (5%) receiving a "Fair" rating in the C category, the majority of people show adequate external rotation capabilities (figure 4 d and e). The overall functional outcome was satisfactory, as indicated by the average Total Score of 87.85.

In Constant-Murley score, majority cases (55%) fall in the score range of 81-90 followed by 40% in 91-100 range and 5% in 71-80, indicating an acceptable overall performance across the investigated scores. The distribution of total score is shown in figure 5. The linear regression of total score is given in table 3 and the association of total pain score with demographic and clinical profile is given in table 4.

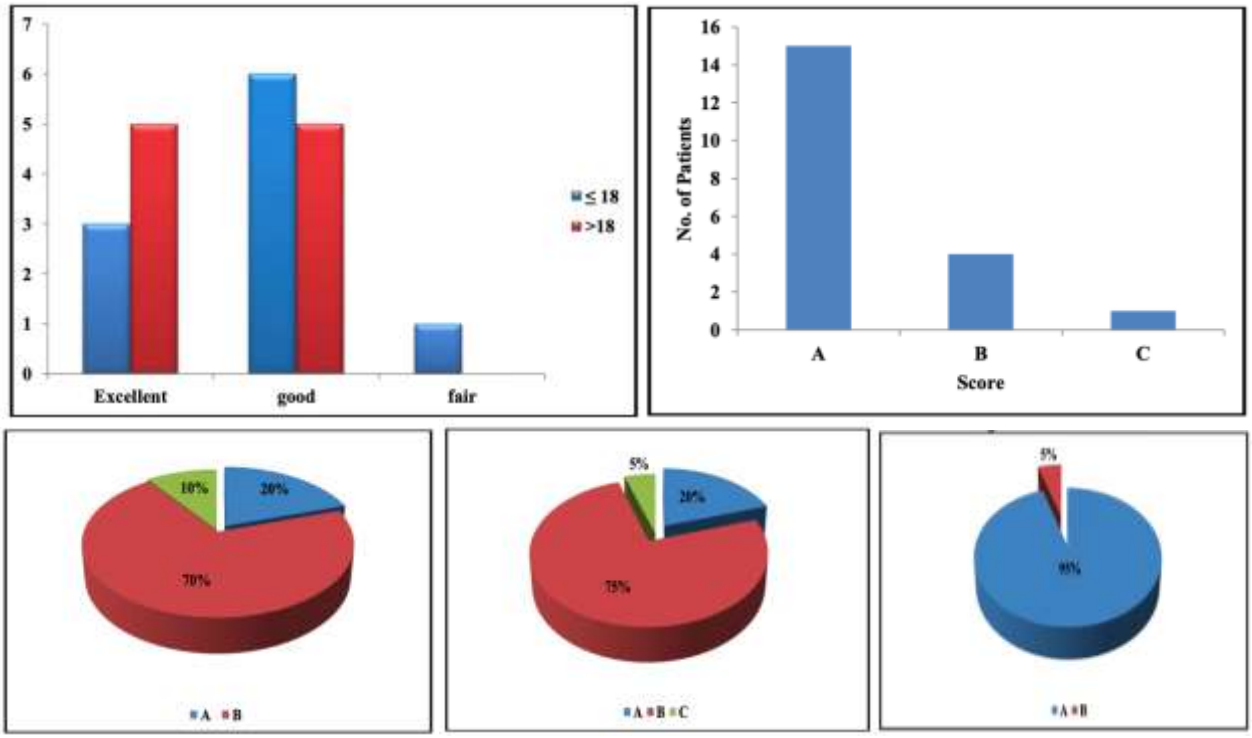


Figure 4. Showing overall pain score in (a)activity living selection score, (b) forward flexion, (c) abduction, (d) external rotation and (e) internal rotation

Table 2. Comparison of pains scores among patients undergone surgery.

	N	Missing	Mean	Median	SD	IQR	Range	Minimum	Maximum
Pain Score	20	0	15	15	0	0	0	15	15
ADL Score	20	0	18.5	19	1.821	2	6	14	20
Forward Flexion Score	20	0	9.4	10	1.142	0.5	4	6	10
Abduction Score	20	0	8.2	8	1.105	0	4	6	10
External Rotation Score	20	0	8.3	8	0.979	0	4	6	10
Internal Rotation Score	20	0	8	8	0	0	0	8	8
Total Score	20	0	87.85	89	4.955	4.5	23	72	95

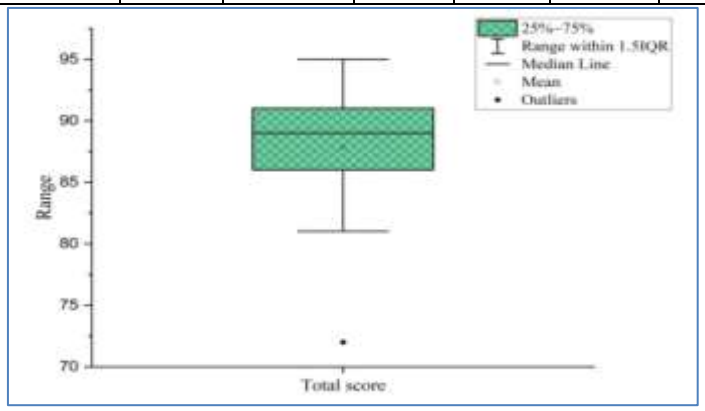


Figure 5. Distribution of Total score

Table 3. Linear Regression analysis for total score

Predictor	Estimate	SE	t	p
Intercept [a]	82.796	11.2577	7.355	< .001
Age (years)	0.0248	0.0528	0.469	0.652
Gender:				
M – F	-1.0298	1.3059	-0.789	0.453
Side:				

R – L	0.8206	1.4432	0.569	0.585
Mode Of Injury:				
Indirect – Direct	0.4293	1.4369	0.299	0.773
Time interval from trauma to surgery (Days)	-0.4084	0.3676	-1.111	0.299
Follow-up duration (Weeks)	0.3342	0.3871	0.863	0.413
Fracture Union (Weeks)	-0.1603	0.2046	-0.783	0.456
Forward Flexion:				
B – A	-5.3182	1.5858	-3.354	**0.01**
C – A	-18.5587	3.3047	-5.616	**< .001**
Blood Loss (ml)	0.0155	0.0119	1.294	0.232
Duration of surgery in hours	-0.5681	1.6147	-0.352	0.734

Table 4. Association of total pain score with demographic variables.

		Result			P
		Excellent	**Good**	**Fair**	
Gender	M	5	9	1	
		62.5 %	81.8 %	100.0 %	
	F	3	2	0	0.529
		37.5 %	18.2%	0.0 %	
	Total	8	11	1	
		100.0 %	100.0 %	100.0 %	
Side	R	6	6	0	
		75.0 %	54.5 %	0.0 %	
	L	2	5	1	0.303
		25.0 %	45.5 %	100.0 %	

	Total	8	11	1	
		100.0 %	100.0 %	100.0 %	
Mode of injury	Indirect	6	8	0	
		75.0 %	72.7 %	0.0 %	
	Direct	2	3	1	0.291
		25.0 %	27.3 %	100.0 %	
	Total	8	11	1	
		100.0 %	100.0 %	100.0 %	
Forward Flexion selection	A	8	7	0	
		100.0 %	63.6 %	0.0 %	
	B	0	4	0	
		0.0 %	36.4 %	0.0 %	
	C	0	0	1	**<0.001**
		0.0 %	0.0 %	100.0 %	
	Total	8	11	1	
		100.0 %	100.0 %	100.0 %	
Activity of Daily Living selection	A	7	7	0	
		87.5 %	63.6 %	0.0 %	
	B	1	4	1	0.156
		12.5 %	36.4 %	100.0 %	
	Total	8	11	1	
		100.0 %	100.0 %	100.0 %	

Complications

Most of the patients (75%) had scored more than 80 in this study, which shows good outcome of the treatment. In our research, shoulder stiffness (20%) and malunion (5%) were the most frequent complications seen in post-surgical treatment.

DISCUSSION

For orthopaedic surgeons, treating proximal humeral fractures surgically is a challenge and brings discussion. Treatment using conventional plates and screws for displaced proximal humerus fractures has been associated with a high prevalence of complications and unsatisfactory outcomes. (Lever et al., 2008). Clinical investigations suggest that proximal humerus locking devices are effective in treating PHF(Gregory et al., 2013; Koukakis et al., 2006; Seide et al., 2007).

In this prospective study, we studied 20 PHF cases that were surgically treated using PHILOS plates at our hospital. To get an optimal complete functional outcome, appropriate anatomical reduction and early fracture fixation are crucial than the implant used. This factor is independent of the implant design and the procedure selected. Our study found that patients with such injuries had an average age of 47.8 years (range 24 to 66 years), which is similar with previous studies by Egol et al. (61 years) and Gerber et al. (44.9 years) (Egol et al., 2008; Gerber et al., 2004). Our study found a high male prevalence (75%), with 7 out of 20 patients falling into the 41-60 age range, a high risk group for osteoporosis. Th fact is that, PHFare more prevalent in elderly adults aged 41 to 70. This occurs due to senile osteoporosis. Our data supports previous age-related research findings. In line with previous studies, our study revealed that men were more likely than women to sustain fractures, most likely as a consequence of their greater involvement in daily activities (bansal et al., 2015; Sharma et al., 2014).

Although the study we conducted was short, previous research has shown that early functional outcomes are similar to long-term effects. The degree of the fracture, anatomical reduction, etiology, bone quality, time from injury to surgery, concomitant injuries, and accurate implant site and fixation all appear to have an influence on the outcome. In our investigation, the mean time from trauma to surgery was 3.6 days, which is consistent with previous studies (Felix Brunner et al.,)found an average gap of 2.9 days (Brunner et al., 2009).

According to Neer's categorization, our study had 45% two-part fractures, 50% three-part fractures, and 5% four-part fractures. Our study found that three-part fractures were the most common fracture form, which is consistent with previous research. Our mean Constant-Murley score of 87.9 was slightly better than findings from western literature, most likely as a result of fewer plate fixation challenges. Thyagarajan and his colleagues, studied in 30 patients with PHF and found an average Constant score of 57.5, a mean age of 58 years (range 19-92 years) (Thyagarajan et al., 2009). Similarly, a prospective research found a mean Constant score of 68.31 in 19 patients, reported the scores ranging from 52 to 72 after ORIF using the PHILOS plate (Kettler et al., 2006).

Hente et al. reported a lower mean score of 55 for fractures with dislocation compared to those without. Despite variations among research (Hente et al., 2004). Thanasis et al. found an overall Constant score of 74.3, with the majority of studies suggesting the use of locking plates for proximal humerus fractures, particularly in older patients with low bone quality (Thanasas et al., 2009). This makes us believe that, through locking plate technology for PHF has an extensive learning curve and that performing surgery properly is vital for achieving a satisfactory functional outcome.

In our study, the average Constant score for 4-part fractures was 72, which was lower than for 2-part and 3-part fractures (88.1 and 89.2, respectively). This finding aligns with an earlier prospective study reported that the mean Constant score for 4-part fractures was substantially lower than that of other types (Sproul et al., 2011).

Another research shows that with a mean Constant score of 85.29, for patients treated with the PHILOS plate had excellent to good functional outcomes in comparison with K-wire fixation (which had a mean Constant score of 79.48 and a lower success rate of 60.86%) supporting our findings which emphasising PHILOS method a better approach in managing proximal humorous fracture (Yadav et al., 2020).
The forward flexion score is a crucial component of the overall shoulder function assessment. It reflects a patient's capacity to elevate their arm forward, which is necessary for daily activities. Successful outcomes in forward flexion and overall shoulder function are strongly dependent on proper patient selection and adherence to rehabilitation protocols (Kumar et al., 2020). Our findings show that significant improvements in forward flexion scores are greatly influenced by patients' demographic and clinical variables, highlighting the individualized treatment approaches and adherence to rehabilitation procedures has been followed strictly.

An earlier studies reported that, in a four-part fracture, the shoulder hemiarthroplasty had better functional outcomes than ORIF with a locking plate. These outcomes are to be expected given the complexity of these fractures and the difficulty of internal fixation and open reduction (Acklin et al., 2013; Jose et al., 2017). In our study, we found that patients in the age groups

under and over 60 had different outcomes and The age group of patients under 60 years responded better. Aggarwal et al. have observed similar results, showing that younger patients had higher Constant scores than older patients (age >65)(Doshi, Sharma, Gudda Naik, et al., 2017) .

Approximately 75 percent of the patients were able to regain their pre-injury activity levels. Also the obtained forward flexion and the abduction selection score (9.4 and 8.2 respectively) it can be justified that most of the patients had good functional activities (Sohn & Shin, 2014).

With the exception of only four patients who experienced shoulder discomfort due to a valgus four-part fracture and another who experienced malunion, all fractures healed satisfactorily. No wound infections, vascular injuries or loss of fixation were noted. Post operatively, there is no complications were observed among the cases (75%) in this study. A malunion was observed in one patient (5%) and shoulder stiffness was observed in 4 (20%) patients were found in our study. All the above findings highlights the fact that, its locking mechanism provides enhanced stability, enabling earlier rehabilitation and better long-term results than traditional fixation methods.

CONCLUSION

Although our study used 20 patients, using PHILOS plates for the surgical management of proximal humeral fractures shows promising and beneficial outcomes, notably in younger patients who recovered more quickly than older patients. The benefits of anatomical reduction and stable fixation are obvious in achieving satisfactory healing and functional restoration. The effectiveness of locking plate technology in treating these fractures is generally supported by this study, which also highlights the significance of surgical technique and patient characteristics in attaining the best outcomes. More extensive research with a greater number of patients is required to validate these results.

AUTHOR CONTRIBUTIONS

The authors contributed equally for its content, writing, and reviewing and/or editing of the manuscript before submission.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors are grateful to the authorities of Aarupadai Veedu Medical College and Hospital, Vinayaka Missions Research Foundation (Deemed to be University) and to all the patients who participated in the study.

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