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Evaluation of Functional Outcome of Proximal Humerus Fractures Treated with PHILOS Plate

Nripen Kumar Kundu*[1], Sathi Dastider[2]

Abstract

Introduction *: Proximal humerus fractures (PHFs) are common, particularly in the elderly, and their optimal surgical management remains a subject of ongoing debate. Locking plate technology, especially the Proximal Humerus Internal Locking System (PHILOS), has been developed to address challenges in osteoporotic and comminuted fractures by enhancing fixation stability.* ***Aim of the study:*** *To evaluate the functional outcome and complication profile of PHFs treated with PHILOS plating in a tertiary care setting.* ***Methods:*** *A prospective observational study was conducted on 32 patients with PHFs treated with PHILOS plate fixation. Demographic and clinical data were recorded, and patients were followed for a minimum of 6 months. Functional outcomes were assessed using the Constant-Murley Score and the Disabilities of the Arm, Shoulder and Hand (DASH) score. Subgroup analyses were performed based on fracture type (Neer classification), and associations between surgical timing, complications, and outcomes were analyzed statistically.* ***Result:*** *The mean age of patient was 55.4 ± 12.9 years, with males comprising 56.25% of the cohort. The majority of injuries resulted from low-energy falls (68.75%). Two-part fractures were the most common (37.5%), followed by three-part (40.63%) and four-part (21.88%) types. The mean Constant-Murley Score at final follow-up was 74.9 ± 9.1, with 43.75% of patients achieving excellent results. Functional outcomes were significantly better in 2-part fractures compared to 4-part fractures ($p = 0.003$). Complications occurred in 31.25% of patients, and were significantly associated with lower Constant scores ($p < 0.001$).* ***Conclusion:*** *PHILOS plating provides satisfactory functional outcomes in proximal humerus fractures, especially in less complex fracture patterns and when surgery is performed early. However, the presence of complications significantly compromises shoulder function. Careful patient selection, timely intervention, and postoperative rehabilitation are crucial for optimal outcomes.*

Keywords: *Proximal humerus fracture, PHILOS plate, Constant-Murley Score, DASH score, fracture fixation, functional outcome, surgical timing, complications.*

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***1. Corresponding Author:**
Dr. Nripen Kumar Kundu
Associate Professor
Department of Orthopaedic Surgery
Popular Medical College Hospital
Dhanmondi, Dhaka, Bangladesh
Email: drnripenkundu@gmail.com
Contact: 01715012020

2. Dr. Sathi Dastider
Associate Professor,
Department of Population Dynamics
National Institute of Preventive and Social Medicine (NIPSOM)
Mohakhali, Dhaka, Bangladesh.

Introduction:

Proximal humerus fractures (PHFs) account for approximately 4–6% of all adult fractures globally and are recognized as the third most common type of fracture in the elderly population, following hip and distal radius fractures[1]. Their prevalence is particularly high in individuals aged over 65, with a marked increase seen among postmenopausal women due to age-related osteoporotic changes that compromise bone density and structural integrity[2]. These fractures commonly result from low-energy trauma such as falls from standing height in elderly individuals, whereas in younger patients, high-energy trauma, including road traffic accidents or sports injuries, is often implicated[3,4]. The unique anatomical and biomechanical complexity of the proximal humerus—consisting of the humeral head, greater and lesser tuberosities, and surgical neck—poses significant challenges in both diagnosis and management[5]. The integrity of the surrounding musculature, particularly the rotator cuff, and the delicate vascular supply—especially the anterior and posterior humeral circumflex arteries—further complicate treatment approaches[6]. Proximal humerus fracture management depends on factors such as fracture pattern, displacement, bone quality, age, activity level, and comorbidities[7,8]. Most non-displaced fractures respond well to conservative treatment with slings, physiotherapy, and monitoring. However, displaced or comminuted fractures often require surgical fixation to restore alignment and function. Classification systems like Neer and AO/OTA aid in guiding treatment and predicting outcomes[8]. Among surgical

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options for displaced proximal humerus fractures—especially Neer's 2-, 3-, and select 4-part types—locking plates have become widely accepted. The PHILOS (Proximal Humerus Internal Locking System) plate, a next generation locking-compression device, is anatomically contoured for the proximal humerus and features multidirectional locking screws, fixed-angle stability, and angular compression. These design elements improve screw purchase in osteoporotic bone, reduce soft-tissue disruption, minimize secondary displacement, and lower hardware failure risk while enabling early mobilization[9]. The biomechanical strength of the PHILOS plate stems from its locking screw-plate interface, which offers angular stability and converts shear forces into compression at the fracture site. This enhances construct integrity and supports early shoulder mobilization—crucial for elderly patients at risk of stiffness. Its compatibility with minimally invasive techniques helps preserve soft tissue, limit periosteal disruption, and maintain humeral head vascularity, all of which promote better healing and functional recovery[10]. Successful PHILOS fixation demands precise surgical technique, including proper fracture reduction, medial calcar restoration, and avoidance of varus malalignment or intra-articular screw penetration. Misplacement can result in complications such as subacromial impingement, screw cut-out, infection, avascular necrosis, or implant failure. Thus, optimal outcomes rely on thorough preoperative planning, meticulous execution, and tailored rehabilitation[11]. Despite these challenges, the PHILOS plate remains a preferred fixation method for proximal humerus fractures due to its biomechanical strength, suitability for osteoporotic bone, and support for early mobilization. It provides an effective solution, particularly where recovery impacts quality of life and independence[12]. This study aims to evaluate functional outcomes in proximal humerus fractures treated with the PHILOS plate, focusing on pain relief, range of motion, complications, and patient satisfaction to assess its effectiveness in modern orthopedic practice.

Materials & Methods:

This was a prospective observational study conducted in the Department of Orthopedic Surgery at Popular Medical College, Dhanmondi, Dhaka, Bangladesh from May 2023 to April 2025. The study was approved by the Institutional Ethics Committee, and informed written consent was obtained from all participants.

A total of 32 patients diagnosed with displaced proximal humerus fractures were included based on predefined eligibility criteria. Patients were selected for operative management with open reduction and internal fixation using the Proximal Humerus Internal Locking System (PHILOS) plate. Inclusion Criteria were Age ≥18 years, Displaced 2-part, 3-part, or 4-part fractures of the proximal humerus (classified as per Neer classification), Fractures treated with PHILOS plate within 10 days of injury and Ability and willingness to provide informed consent and comply with postoperative follow-up protocol. Exclusion Criteria were Pathological fractures or open fractures, Polytrauma patients with other major musculoskeletal injuries, Patients with ipsilateral upper limb fractures, Pre-existing shoulder pathology or neuromuscular disorders affecting shoulder function and Patients lost to follow-up or non-compliant with rehabilitation. Surgical Technique: All procedures were performed under general or regional anesthesia in a standardized manner. A deltopectoral approach was used in all cases. Fracture fragments were anatomically reduced under direct visualization and temporarily stabilized with K-wires, followed by definitive fixation using the PHILOS plate. Intraoperative fluoroscopy was used to confirm fracture reduction and hardware placement. Postoperative radiographs were taken in two standard planes. Postoperative Rehabilitation: A standardized rehabilitation protocol was followed. Passive range of motion exercises were initiated from the second postoperative day. Active-assisted and active shoulder exercises were gradually introduced after radiographic signs of fracture union, typically around 6–8 weeks post-surgery. Data Collection and Outcome Measures: Demographic and clinical data, including age, gender, limb dominance, mechanism of injury, fracture classification (Neer), time from injury to surgery, and presence of comorbidities, were recorded. Intraoperative variables such as operative time, blood loss, and duration of hospital stay were noted. The primary outcome measure was the Constant-Murley Shoulder Score, assessed at the final follow-up (minimum 6 months postoperatively), which evaluated pain, activities of daily living, range of motion, and strength. The Disabilities of the Arm, Shoulder and Hand (DASH) score was also recorded as a secondary outcome. Radiological union was assessed via serial radiographs. Statistical Analysis: All data were analyzed using IBM SPSS Statistics Version 26. Descriptive statistics were presented as mean ± standard deviation (SD) for continuous variables and as frequencies and percentages for categorical variables. Comparative analysis of functional scores across fracture types was performed using one-way analysis of variance (ANOVA). Independent samples t-test was used to evaluate the association between postoperative complications and functional outcomes. Pearson's correlation coefficient was applied to assess the relationship between time to surgery and Constant score. A p-value <0.05 was considered statistically significant.

Result:

A total of 32 patients with proximal humerus fractures treated with PHILOS plate fixation were included in this study. The mean age of the study population was 55.4 ± 12.9 years, with the majority (46.9%) aged between 51 and 60 years. There were 18 males (56.25%) and 14 females (43.75%). Right-side involvement occurred in 17 cases (53.125%), and the dominant limb was affected in 21 patients (65.625%). Low-energy falls were the leading cause of injury (n = 22, 68.75%). The median time from injury to surgery was 4 days [IQR 3–6]. Based on Neer classification, 3-part fractures were most common (n = 13), followed by 2-part (n = 12) and

4-part (n = 7). Comorbidities included hypertension (n = 10), diabetes (n = 6), and osteoporosis (n = 4), as shown in Table I. The mean operative time was 93.2±15.8 minutes, with blood loss averaging 165.7±42.6 ml. Hospital stay averaged 5.9±2.2 days. Radiographic union was achieved at 12.7±2.8 weeks. Shoulder mobilization began at a median of 9 weeks. No postoperative complications were seen in 22 patients. Superficial infection and implant-related issues occurred in 3 patients each, while avascular necrosis and frozen shoulder were noted in 2 patients each (Table II). Functional outcomes, assessed using the Constant-Murley Score at final follow-up. The mean scores for subdomains were: Pain 13.2 ± 1.7, Activities of Daily Living 16.8 ± 2.4, Range of Motion 30.7 ± 3.9, and Strength 14.2 ± 2.5, resulting in a mean total Constant score of 74.9 ± 9.1. Based on total Constant scores, 43.8% of patients achieved excellent outcomes, 25.0% good, 21.9% fair, and 9.4% poor (Table III).The comparison of DASH scores across fracture types showed the lowest mean in 2-part fractures (23.2±7.1), followed by 3-part (27.6±6.4), and the highest in 4-part fractures (34.4±8.6), with significant difference (p = 0.004), as demonstrated in Table IV. Constant sub-scores favored 2-part fractures with mean total score of 78.2±7.0 compared to 74.2±8.3 in 3-part and 66.5±9.6 in 4-part fractures (p = 0.003) (Table V). As represented in Table VI, patients without complications (n = 22) had a higher Constant score (78.1±6.9) compared to those with complications (66.8±8.4). Figure 1 illustrates the radiographic, intraoperative, and clinical management of a representative proximal humerus fracture treated with a PHILOS plate. Preoperative radiographs (Figure 1A) show the fracture configuration. Intraoperative images (Figure 1B) demonstrate the reduction and fixation using the PHILOS plate. Postoperative clinical photographs (Figure 1C) show the surgical wound with sutures, indicating appropriate soft-tissue closure, while postoperative radiographs (Figure 1D) confirm stable fixation and satisfactory alignment.

Table I: Baseline demographic and clinical characteristics of the study population (N = 32)

Variable	Frequency (n)	Percentage (%)
Age (years)		
<20	2	6.25
21-30	5	15.625
31-40	3	9.375
41-50	6	18.75
51-60	15	46.875
Mean ± SD	55.4 ± 12.9	55.4 ± 12.9
Gender		
Male	18	56.25
Female	14	43.75
Side involved		
Right	17	53.125
Left	15	46.875
Dominant limb involved		
Yes	21	65.625
No	11	34.375
Mechanism of injury		
Low-energy fall	22	68.75
Road traffic accident	7	21.875
Others	3	9.375
Time from injury to surgery (days), median [IQR]	4 [3–6]	4 [3–6]
Fracture pattern (Neer classification)		
2-part	12	37.50
3-part	13	40.63
4-part	7	21.88
Comorbidities		
Hypertension	10	31.25
Diabetes	6	18.75
Osteoporosis	4	12.50

Table II: Intraoperative and postoperative characteristics of patients undergoing PHILOS fixation (N = 32)

Parameter	Value
Operative time (minutes), mean ± SD	93.2 ± 15.8
Blood loss (ml), mean ± SD	165.7 ± 42.6
Hospital stay (days), mean ± SD	5.9 ± 2.2
Time to radiographic union (weeks), mean ± SD	12.7 ± 2.8
Time to shoulder mobilization (weeks), median [IQR]	9 [8–10]
Postoperative complications, n (%)	
None	22 (68.75)
Superficial infection	3 (9.38)
AVN	2 (6.25)
Implant-related	3 (9.38)
Frozen shoulder	2 (6.25)

Table III: Functional outcome based on Constant-Murley score among the study population

Parameter	Score Range	Value
Subdomain Scores (Constant-Murley Score) , Mean ± SD		
Pain	0–15	13.2 ± 1.7
ADL (Activities of Daily Living)	0–20	16.8 ± 2.4
Range of Motion (ROM)	0–40	30.7 ± 3.9
Strength	0–25	14.2 ± 2.5
Total Constant Score	0–100	74.9 ± 9.1
Score Category, n (%)		
Excellent	>85	14 (43.75)
Good	70–85	8(25.00)
Fair	55–69	7(21.88)
Poor	<55	3(9.38)

Table IV: Comparison of Mean DASH Scores Based on Neer Fracture Classification

Neer Type	n	Mean DASH Score ± SD	95% CI	p-value (ANOVA)
2-part	12	23.2 ± 7.1	19.1 – 27.3	0.004
3-part	13	27.6 ± 6.4	23.6 – 31.6	
4-part	7	34.4 ± 8.6	27.6 – 41.2	

Table V: Comparison of Constant-Murley sub-scores according to fracture type

Score Component	2-part (n = 12) Mean ± SD	3-part (n = 13) Mean ± SD	4-part (n = 7) Mean ± SD	p-value (ANOVA)
Pain	13.7 ± 1.3	13.0 ± 1.8	12.0 ± 2.1	0.041*
ADL	17.5 ± 1.7	16.5 ± 2.6	15.1 ± 2.9	0.038*
ROM	32.2 ± 3.1	30.4 ± 4.0	27.9 ± 4.2	0.027*
Strength	14.8 ± 2.1	14.1 ± 2.3	12.5 ± 2.7	0.049*
Total Constant Score	78.2 ± 7.0	74.2 ± 8.3	66.5 ± 9.6	0.003

Table VI: Association between postoperative complications and functional outcome

Complication Status	n	Mean DASH Score ± SD	p-value (t-test)
No complications	22	78.1 ± 6.9	<0.001
With complications	10	66.8 ± 8.4	

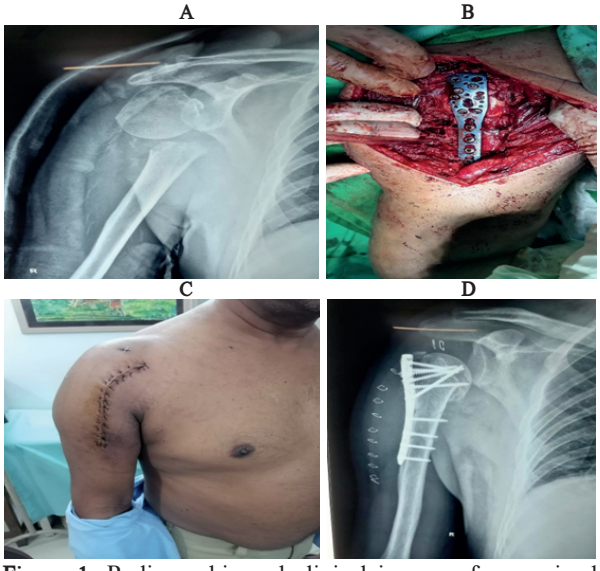

Figure 1: Radiographic and clinical images of a proximal humerus fracture treated with PHILOS plate:

(A) Preoperative radiograph showing displaced proximal humerus fracture.

(B) Intraoperative image demonstrating PHILOS plate fixation.

(C) Immediate postoperative clinical photograph showing surgical incision.

(D) Postoperative radiograph confirming stable fixation with PHILOS plate.

Discussion:

Proximal humerus fractures represent the third most common fracture type in the elderly population, accounting for nearly 5–6% of all adult fractures, with incidence expected to rise due to aging demographics and increasing rates of osteoporosis[13]. The management of displaced fractures, especially three- and four-part types, remains controversial owing to complex anatomy, compromised bone quality, and risk of avascular necrosis. Locking plate technology, particularly the Proximal Humerus Internal Locking System (PHILOS), was introduced to improve angular stability and facilitate early mobilization in osteoporotic bone[14]. Nevertheless, its effectiveness continues to be debated, especially in complex fractures[15]. In this context, the present study was conducted to evaluate the functional outcomes of proximal humerus fractures managed surgically using the Proximal Humerus Internal Locking System (PHILOS) plate. In our study, the mean age of patients was 55.4 ± 12.9 years, with the majority being older than 50 years, reflecting the epidemiological trend of fragility-related proximal humerus fractures[16]. Males comprised 56.25% of the study population. This gender distribution aligns closely with findings reported by Aliuddin AM et al[17]. although their study differed in age composition, with only 30% of patients aged over 50 years. Similarly, Thakur et al[9]. documented a male predominance, which concurs with the results observed in the current study. Low-energy trauma, particularly falls from standing height, was the predominant cause (68.75%), consistent with findings reported in earlier studies by Court-Brown et al. and Roux et al.[19-20]. Radiographically, 2-part and 3-part fractures accounted for approximately 78% of cases in the present study, which aligns with previous findings. Petros et al. (2016) reported that 82% of surgically treated proximal humerus fractures were either 2-part or 3-part types, managed with PHILOS locking plates[21]. Similarly, a Brazilian cohort study (2013) found that 64% of cases fell into these categories[22]. The mean time from injury to surgery was 4 days, which appears crucial, as delayed intervention showed a modest inverse correlation with functional outcomes ($r = –0.34$; $p = 0.032$). In the present study, the mean operative time was 93.2 ± 15.8 minutes, comparable to Doshi et al., who reported 94 ± 10.2 minutes[23]. In the present study, the mean operative time was 93.2 ± 15.8 minutes and mean intraoperative blood loss was 165.7 ± 42.6 ml, both of which fall within the acceptable range reported in previous PHILOS-based fixation studies. Brunner et al. reported operative durations between 90 to 120 minutes in a large prospective multicenter cohort of proximal humerus fracture cases treated with locking plates[24]. Functionally, the mean Constant-Murley Score was 74.9 ± 9.1 at final follow-up, with 43.75% of patients achieving excellent outcomes. These findings are comparable to those of Sudkamp et al., who observed a mean Constant score of 72 in a multicenter PHILOS study[25]. Similarly, Erasmo et al. documented a mean score of 75, with 73% achieving good to excellent results[26], while Geiger et al. observed a slightly lower mean score of 67.5 ± 23.6 and 57.1% favorable outcomes[27]. Our subdomain analysis revealed that range of motion (mean 30.7 ± 3.9) and activities of daily living (mean 16.8 ± 2.4) were particularly preserved, suggesting that anatomical restoration and stable fixation were effectively achieved. In the present study, the mean DASH score was 27.9 ± 8.3, indicating a functionally satisfactory outcome following PHILOS fixation. This finding aligns with existing literature; Chodavarapu et al. reported a mean DASH score of 16.2, while Thakur et al. observed a score of 21.3, both supporting the efficacy of PHILOS in selected proximal humerus fractures[28,18]. Fracture complexity was found to significantly impact functional outcomes in the present study. As detailed in Table 6, patients with 2-part fractures achieved notably higher mean Constant scores (78.2 ± 7.0) compared to those with 4-part fractures (66.5 ± 9.6), with statistically significant differences observed across all subdomains ($p < 0.05$). Additionally, lower DASH scores were noted in simpler fractures ($p < 0.05$). These results corroborate findings by Sudkamp et al. and Ockert et al., highlighting that increased fracture severity is associated with poorer recovery due to greater soft tissue injury and compromised vascularity[25,29]. Similarly, Sproul et al.'s systematic review demonstrated a progressive decline in Constant scores with rising fracture complexity, confirming superior outcomes in 2-part versus 4-part fractures ($p < 0.01$)[30]. Postoperative complications were observed in 31.25% of patients, including superficial infections,

implant-related issues, frozen shoulder, and AVN. Notably, patients without complications demonstrated significantly better functional outcomes (mean Constant score: 78.1 ± 6.9 vs. 66.8 ± 8.4; $p < 0.001$), reaffirming the critical role of meticulous surgical technique and early rehabilitation in optimizing recovery . These rates are consistent with those reported in prior literature, where complication rates range from 20% to 35%[31]. Furthermore, time to radiographic union averaged 12.7 ± 2.8 weeks, and shoulder mobilization commenced at a median of 9 weeks. These findings are broadly consistent with prior literature. Garg et al. and other investigators have reported union typically occurring by 12 weeks in conservatively or operatively managed proximal humerus fractures[32]. Moreover, multiple studies, including those by Lefevre-Colau et al. and Torrens et al., demonstrated that early initiation of shoulder mobilization—often within 1 to 3 weeks—leads to superior early functional recovery without compromising fracture healing[33].

Conclusion and Recommendations:

PHILOS plate fixation offers reliable functional recovery for proximal humerus fractures, with most patients achieving excellent or good outcomes. Functional results decline with increasing fracture complexity, particularly in 4-part fractures, and are adversely affected by postoperative complications. Careful surgical technique and early management of complications are essential. Overall, PHILOS plating is an effective treatment, especially for 2- and 3-part fractures, facilitating early mobilization and restoration of shoulder function.

Conflict of Interest: None.

Ethical approval: The study was approved by the Institutional Ethics Committee.

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