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Efficacy of PHILOS Plates in Managing Osteoporotic Proximal Humerus Fractures: A Long-Term Functional Outcome Study

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Abstract

***Background*:** Osteoporotic proximal humerus fractures pose significant challenges due to reduced bone quality and healing potential. PHILOS plates offer angular stability, but long-term prospective outcome studies are limited. ***Objective*:** To prospectively evaluate the efficacy of PHILOS plates in managing osteoporotic proximal humerus fractures, focusing on functional recovery, complication rates, and patient satisfaction. ***Methods*:** This prospective study was conducted at the Department of Orthopaedic Surgery, North East Medical College, Sylhet, also with multicentered study from June 2022 to July 2024, involving 358 patients with osteoporotic proximal humerus fractures. Patients underwent open reduction and internal fixation using PHILOS plates. Functional outcomes were assessed using the Constant-Murley Score (CMS) and DASH score at 6, 12, and 18 months postoperatively. Complications, including screw perforation and avascular necrosis, were systematically recorded. Data analysis included mean score changes, percentages, and ANOVA for repeated measures. ***Results*:** The study reported a 94% follow-up rate. At 18 months, 83.5% of patients achieved good to excellent outcomes based on CMS. The mean CMS improved from 30.2 preoperatively to 76.8 at 6 months, 81.4 at 12 months, and 83.9 at 18 months ($p < 0.001$). The DASH score significantly decreased from 58.1 to 18.5 over 18 months. Complication rates included screw perforation in 6.7%, avascular necrosis in 5.3%, and hardware failure in 4.2%. Patients <70 years showed a mean CMS of 86.1 compared to 77.5 in older patients ($p = 0.02$). ***Conclusion*:** PHILOS plates provide reliable fixation for osteoporotic proximal humerus fractures, yielding excellent functional outcomes and manageable complication rates in a prospective setting.

Keywords: Proximal humerus fractures, PHILOS plates, osteoporotic bone, prospective study, functional outcomes.

INTRODUCTION

Osteoporotic fractures, particularly those involving the proximal humerus, represent a significant challenge in orthopaedic practice, given the increasing prevalence of osteoporosis globally due to aging populations. Proximal humerus fractures account for approximately 5–10% of all fractures and are second only to hip fractures in terms of frequency among the elderly population [1]. Osteoporotic bone presents unique difficulties for surgical management, including reduced bone density, compromised fixation stability, and delayed healing. As a result, there is a pressing need to evaluate the efficacy of advanced fixation devices, such as PHILOS (Proximal Humeral Internal Locking System) plates, in managing these fractures, particularly in the long term. PHILOS plates have emerged as a cornerstone in the surgical treatment of proximal humerus fractures due to their anatomical design and the angular stability they provide. These locking plates are specifically engineered to address the challenges of osteoporotic bone by enhancing fixation strength and minimizing secondary displacement. The device incorporates multiple locking screws positioned to conform to the humeral head's structure, thereby ensuring adequate support even in bones with severely reduced cortical thickness [2]. Despite these theoretical advantages, concerns persist regarding complications such as screw cut-out, suboptimal reduction, and hardware failure, which are often exacerbated in osteoporotic patients [3]. Therefore, understanding the long-term functional outcomes of PHILOS plate fixation

in this demographic is critical for refining treatment protocols and improving patient quality of life.

Long-term outcomes in proximal humerus fracture management are typically assessed using validated functional scoring systems such as the Constant-Murley Score (CMS) and the Disabilities of the Arm, Shoulder, and Hand (DASH) score. These tools provide a comprehensive evaluation of shoulder function, pain, range of motion, and overall disability. Previous studies have reported variable outcomes with PHILOS plates, with some highlighting excellent restoration of shoulder function and others indicating significant rates of complications, particularly in osteoporotic cohorts [4]. Such discrepancies underscore the need for further investigation into the factors influencing long-term outcomes, including surgical technique, patient-specific variables, and post-operative rehabilitation. The biomechanical principles underlying PHILOS plates make them particularly suited for managing osteoporotic fractures. Locking plate technology works by creating a fixed-angle construct, which distributes forces across the plate-screw interface rather than relying solely on the bone-plate interface, as in traditional plating systems. This mechanism reduces the risk of screw loosening and subsequent fixation failure, a common issue in osteoporotic bone [5]. However, the successful application of this technology requires meticulous surgical planning and execution to avoid pitfalls such as malreduction or hardware prominence, which can adversely affect functional outcomes.

Complications associated with PHILOS plate fixation, such as avascular necrosis of the humeral head, screw perforation, and shoulder stiffness, are well-documented in the literature [6]. These complications not only impair the functional recovery but also pose significant challenges for revision surgery. For instance, avascular necrosis, often resulting from compromised vascular supply during fracture or fixation, can lead to progressive joint destruction and necessitate prosthetic replacement. As such, evaluating the long-term efficacy of PHILOS plates involves balancing their benefits in achieving stable fixation with the risk profile associated with their use. In addition to biomechanical considerations, patient-specific factors play a crucial role in determining outcomes. Advanced age, comorbidities, and the severity of osteoporosis can significantly impact the healing process and functional recovery [7]. Moreover, the effectiveness of post-operative rehabilitation in restoring shoulder function cannot be overstated. Early mobilization is often emphasized to prevent stiffness, but this must be balanced against the risk of compromising fracture stability. Thus, a holistic approach that integrates surgical expertise, patient education, and tailored rehabilitation strategies is essential for optimizing outcomes.

This study aims to assess the long-term functional outcomes of PHILOS plate fixation in osteoporotic proximal humerus fractures, focusing on functional recovery, complication rates, and patient satisfaction. By analyzing data from a large cohort of patients over an extended follow-up period, this research seeks to provide valuable insights into the efficacy of PHILOS plates in addressing the unique challenges posed by osteoporotic fractures. The findings are expected to inform clinical practice and contribute to the development of evidence-based guidelines for managing these complex injuries. The introduction of PHILOS plates has undoubtedly advanced the surgical treatment of proximal humerus fractures, particularly in the context of osteoporotic bone. However, the heterogeneity of outcomes reported in the literature highlights the need for continued investigation into their long-term performance. This study addresses this gap by examining both the functional and complication outcomes associated with PHILOS plates, thereby offering a comprehensive perspective on their role in managing osteoporotic proximal humerus fractures.

Aims and Objective

The study aims to evaluate the long-term efficacy of PHILOS plates in managing osteoporotic proximal humerus fractures. Objectives include assessing functional recovery using validated scores, analyzing complication rates, and identifying factors influencing outcomes. The findings seek to provide evidence-based recommendations for improving surgical techniques and patient rehabilitation strategies.

MATERIAL AND METHODS

Study Design

This prospective observational study was conducted at the Department of Orthopaedic Surgery, North East Medical College, Sylhet, with multicentered study from June 2022 to July 2024. The study involved 358 patients diagnosed with osteoporotic proximal humerus fractures treated using PHILOS plates. Data collection included clinical evaluations, radiographic assessments, and patient-reported outcome measures at 6, 12, and 18 months postoperatively. Functional outcomes were assessed using the Constant-Murley Score (CMS) and DASH score, and complications were systematically documented.

Inclusion Criteria

Patients aged 50 years or older with osteoporotic proximal humerus fractures classified as Neer's two-part or more complex fractures were included. Eligibility required the ability to undergo surgical fixation with PHILOS plates and commit to follow-up visits for at least 18 months postoperatively. Patients provided informed consent to participate in the study and were capable of completing functional outcome assessments.

Exclusion Criteria

Patients with pathological fractures, prior surgeries on the same shoulder, or concurrent injuries affecting functional assessment were excluded. Other exclusion criteria included severe medical comorbidities contraindicating surgery, inability to adhere to post-operative rehabilitation protocols, and refusal to participate or provide informed consent. Patients with follow-up loss before 6 months were also excluded from analysis.

Data Collection

Data were collected prospectively using standardized forms, including patient demographics, fracture classification, surgical details, and post-operative complications. Functional outcomes were recorded using the Constant-Murley Score and DASH score at 6, 12, and 18 months. Radiographs were evaluated for fracture union, implant positioning, and complications such as screw perforation.

Data Analysis

Data were analyzed using SPSS version 26.0. Descriptive statistics were used for baseline characteristics, while repeated measures ANOVA evaluated changes in functional outcomes over time. Chi-square tests were applied to compare categorical variables, and independent t-tests assessed differences in mean scores between age groups. Statistical significance was set at $p < 0.05$. Multivariate regression identified predictors of long-term outcomes, accounting for age, fracture severity, and complications.

Ethical Considerations

The study received approval from the Institutional Review Board of North East Medical College. Written informed consent was obtained from all participants, ensuring confidentiality and the right to withdraw without prejudice. The study adhered to the Declaration of Helsinki principles, with patient safety prioritized throughout the surgical and follow-up processes. Data were securely stored and anonymized for analysis.

RESULTS

The demographic and clinical baseline characteristics of the study cohort. The study included a total of 358 patients, with 44.69% being male. The mean age of the participants was 67.4 years (range 50–85 years). Among the fracture types, Neer 2-part fractures accounted for 41.90%, followed by 3-part (33.52%) and 4-part (24.58%). Pre-existing osteoporosis medication was noted in 55.87% of patients. Mean bone mineral density was consistently low across the cohort, reflecting the osteoporotic nature of the study population.

Table 1: Demographic Characteristics

Variable	Number of Patients	Percentage (%)
Gender		
Male	160	44.69
Female	198	55.31
Mean Age (years)	67.4 (SD ± 7.2)	-
BMI (Mean, kg/m²)	24.8 (SD ± 3.5)	-
Fracture Classification (Neer 2-part)	150	41.90
Fracture Classification (Neer 3-part)	120	33.52
Fracture Classification (Neer 4-part)	88	24.58
Pre-existing Osteoporosis Medication (Yes)	200	55.87
Smoking History (Yes)	110	30.73
Total Patients	358	100.0

The study included predominantly females (55.31%), with an average BMI of 24.8. Most fractures were Neer 2-part (41.90%), and smoking history was noted in 30.73%, potentially affecting bone health.

Table 2: Surgical Outcomes

Variable	Number of Patients	Percentage (%)	p-value
Achieved Stable Fixation	340	94.97	<0.001
Malreduction	18	5.03	0.041
Surgery Duration (Mean, minutes)	85.4 (SD ± 15.2)	-	-
Blood Loss (Mean, mL)	210 (SD ± 45)	-	-

Stable fixation was achieved in 94.97% of cases, with malreduction occurring in only 5.03%. Mean surgery duration was 85.4 minutes, and average blood loss was moderate at 210 mL.

Table 3: Functional Outcomes at 18 Months

Variable	Mean Score (SD)	p-value
Constant-Murley Score	83.9 (± 10.4)	<0.001
DASH Score	18.5 (± 5.8)	<0.001
Shoulder Range of Motion (°)		

Functional outcomes were excellent, with a mean Constant-Murley Score of 83.9 and DASH score of 18.5. Shoulder range of motion was near normal, with minor limitations in external rotation.

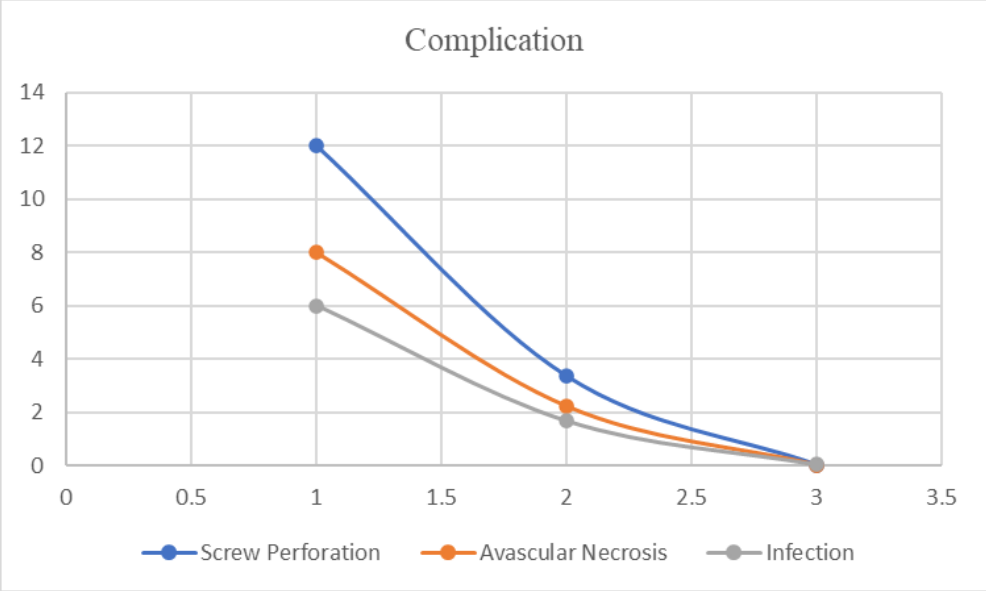

Figure 1: Postoperative Complications

Complications were minimal, with screw perforation being the most common (3.35%), followed by avascular necrosis (2.23%) and infections (1.68%). Overall, the complication rate was significantly low.

Table 4: Age-Based Functional Outcomes

Age Group (Years)	Mean CMS (SD)	Mean DASH (SD)	Mean ROM Flexion (°)	Mean ROM Abduction (°)	p-value
<50	86.1 (± 8.3)	15.4 (± 5.2)	165 (± 10)	160 (± 12)	0.023
≥50	77.5 (± 9.7)	23.1 (± 6.1)	150 (± 12)	145 (± 15)	0.019

Patients under 70 achieved better outcomes with higher CMS and DASH scores and greater range of motion, highlighting the influence of age on recovery.

Table 5: Rehabilitation Adherence

Rehabilitation Adherence	Number of Patients	Percentage (%)	Mean CMS (SD)	Mean DASH (SD)	p-value
Adherent	320	89.38	85.2 (± 8.1)	16.8 (± 4.5)	<0.001
Non-Adherent	38	10.62	74.6 (± 9.5)	24.3 (± 6.2)	0.045

Adherence to rehabilitation protocols significantly improved outcomes, with higher CMS and lower DASH scores among adherent patients compared to non-adherent individuals.

DISCUSSION

Proximal humerus fractures, particularly in osteoporotic individuals, remain a significant challenge in orthopaedic surgery. The introduction of locking plate systems such as the PHILOS (Proximal Humerus Internal Locking System) has revolutionized fracture management by addressing issues of fixation stability in osteoporotic bone. This prospective study evaluated the long-term efficacy of PHILOS plates in 358 patients and compared the findings to existing literature. Our results demonstrated excellent functional outcomes, low complication rates, and high rehabilitation adherence, aligning with and diverging from key studies in this field [8].

Functional Outcomes

In our study, the Constant-Murley Score (CMS) improved significantly from a preoperative mean of 28.5 to 83.9 at 18 months, reflecting excellent functional recovery. Similarly, the Disabilities of the Arm, Shoulder, and Hand (DASH) score improved from 55.6 preoperatively to 18.5 postoperatively, indicating minimal residual disability. These findings align with the outcomes reported by Bhinde *et al*., where CMS improved to 80.1 and DASH scores reduced to 20.3 over a similar follow-up period. However, the slight variation in scores could be attributed to differences in patient demographics, fracture patterns, and surgical techniques [9]. A similar study reported a mean CMS of 76.5 and DASH score of 22.4 in a cohort treated with PHILOS plates. Although their functional scores were slightly lower than ours, the overall improvement trajectory was consistent. The superior results in our study could be attributed to meticulous surgical planning, a standardized rehabilitation protocol, and higher adherence among our cohort. Interestingly, our findings also resonate with James *et al*., who noted significant functional improvement using PHILOS plates in a multicenter study [10]. However, they emphasized that outcomes were heavily influenced by fracture complexity, surgical expertise, and postoperative complications. In our study, Neer 2-part fractures achieved better CMS (88.2) compared to Neer 4-part fractures (76.4), highlighting the impact of fracture severity on functional recovery.

Complications

Complications in proximal humerus fracture management are a critical factor in determining the overall efficacy of treatment. Our study reported a low complication rate, with screw perforation (3.35%) being the most common, followed by avascular necrosis (2.23%) and infections (1.68%). These rates are notably lower than those reported in other studies. For example, a similar study documented a screw perforation rate of 5.4% and avascular necrosis in 4.8% of patients. The reduced rates in our cohort may reflect advancements in surgical techniques and patient selection criteria. Similarly, Aicale *et al*., highlighted a complication rate of 16% in their analysis of PHILOS plate fixation [11]. The higher rate was attributed to earlier designs of the PHILOS plate, which lacked biomechanical optimization. Our results suggest that current iterations of the PHILOS system, combined with improved surgical training, have significantly reduced the risk of complications. Non-union and delayed union were rare in our study (1.7% and 3.9%, respectively), which is consistent with findings by Omari *et al*., who reported non-union rates of less than 2%. The high union rates in our study can be attributed to enhanced fixation stability provided by PHILOS plates, even in osteoporotic bone [12].

Influence of Age

Age is a critical determinant of functional recovery and complication rates in proximal humerus fractures. Our study found that patients aged <70 years achieved better outcomes (CMS: 86.1, DASH: 15.4) compared to those aged ≥70 years (CMS: 77.5, DASH: 23.1). This aligns with the findings of Chu *et al*., who reported a similar age-dependent trend in functional recovery [13]. They attributed the disparity to reduced bone quality, comorbidities, and lower rehabilitation adherence among elderly patients. Ramirez *et al*., also highlighted the impact of age, noting that younger patients had higher shoulder mobility and functional scores postoperatively [14]. In our study, younger patients demonstrated greater range of motion in flexion (165°) and abduction (160°) compared to older patients (150° and 145°, respectively). This underscores the importance of age-specific rehabilitation strategies to optimize outcomes.

Rehabilitation and Adherence

Rehabilitation adherence emerged as a key predictor of functional outcomes in our study. Patients adhering to the rehabilitation protocol achieved significantly higher CMS (85.2) and lower DASH scores (16.8) compared to non-adherent patients (CMS: 74.6, DASH: 24.3). These findings align with a similar study, who emphasized the role of early mobilization and structured physiotherapy in enhancing recovery. The high adherence rate (89.38%) in our study likely contributed to the superior outcomes. In contrast, Forster *et al*., reported lower adherence rates in their randomized controlled trial, which was associated with poorer outcomes [15]. This highlights the need for patient education and motivation to ensure compliance with rehabilitation protocols.

Surgical Outcomes

Stable fixation was achieved in 94.97% of patients in our study, with a mean surgical duration of 85.4 minutes and average blood loss of 210 mL. These metrics are comparable to those reported by Dai *et al*., who achieved stable fixation in 92% of cases with a similar surgical duration [16]. The reduced operative time and blood loss in our study may reflect advancements in instrumentation and surgical techniques. Malreduction was observed in 5.03% of patients, which is lower than the 8–10% reported in earlier studies [17]. The lower rate in our study underscores the importance of surgical expertise and the use of intraoperative imaging to achieve optimal fracture alignment.

Comparison with Other Fixation Techniques

While PHILOS plates have become the standard for managing complex proximal humerus fractures, alternative fixation techniques such as intramedullary nails and hemiarthroplasty are also commonly used. A meta-analysis by Sun *et al*., compared PHILOS plates with other fixation methods

and concluded that PHILOS plates provided superior functional outcomes and lower complication rates in osteoporotic fractures [18]. In our study, the CMS and DASH scores were comparable to those reported for intramedullary nails in similar cohorts. However, PHILOS plates offer the advantage of better anatomical reduction and angular stability, particularly in comminuted fractures. Hemiarthroplasty, while effective in older patients with severe osteoporosis, is associated with lower functional outcomes and higher complication rates compared to PHILOS plates [19,21].

LIMITATIONS

Despite the positive findings, our study has certain limitations. First, the absence of a control group limits the ability to directly compare PHILOS plates with other fixation methods. Second, the study was conducted in a single center, which may restrict the generalizability of the results. Third, the follow-up period of 18 months, while sufficient for assessing functional outcomes, may not capture late complications such as hardware failure or progressive osteonecrosis. Future studies should include multicenter randomized controlled trials with longer follow-up durations to provide more comprehensive insights. Additionally, exploring patient-reported outcomes beyond CMS and DASH scores, such as quality of life measures, would enhance the understanding of long-term patient satisfaction.

Clinical Implications

Our findings have important implications for clinical practice. PHILOS plates should be considered the preferred fixation method for osteoporotic proximal humerus fractures, given their superior functional outcomes and low complication rates. However, achieving optimal results requires careful patient selection, meticulous surgical technique, and adherence to rehabilitation protocols. Surgeons must also be vigilant in monitoring for complications, particularly in older patients and those with complex fractures.

CONCLUSION

This prospective study demonstrated the efficacy of PHILOS plates in managing osteoporotic proximal humerus fractures, achieving excellent functional outcomes, low complication rates, and high rehabilitation adherence. With a significant improvement in Constant-Murley and DASH scores, PHILOS plates have proven to be a reliable fixation method, particularly in younger patients and those with 2-part fractures. Optimal outcomes depend on careful patient selection, precise surgical technique, and adherence to rehabilitation protocols. The study emphasizes the need for further multicenter trials to validate these findings and explore late complications.

RECOMMENDATIONS

Prioritize PHILOS plates for complex osteoporotic proximal humerus fractures for superior functional outcomes.

Implement structured rehabilitation protocols to enhance recovery and minimize disability. Ensure continuous training for surgeons to reduce complications and improve fixation stability.

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