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Evaluation of Functional and Radiological Outcomes of Open Reduction and Internal Fixation Using Locking Plate System in Complex Proximal Humerus Fractures

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ABSTRACT

Background: Proximal humerus fractures account for about 4–5% of all fractures and are common injuries of the shoulder, especially in elderly patients due to osteoporosis. Displaced three-part and four-part fractures are challenging to treat and often lead to poor functional outcomes if not managed properly. Locking plate systems, such as the PHILOS plate, were developed to provide stable fixation, particularly in osteoporotic bone, and to allow early shoulder mobilization.
Objective: To evaluate the functional and radiological outcomes of open reduction and internal fixation using a PHILOS locking plate in patients with complex proximal humerus fractures.
Methods: This combined prospective and retrospective observational study was conducted at a tertiary care orthopaedic center. A total of 50 patients with three-part and four-part proximal humerus fractures treated with PHILOS plating were included. Functional outcome was assessed using the DASH score at 1, 3, and 6 months. Radiological evaluation included fracture union, head shaft angle, and implant position.
Results: Patient ages ranged from 20 to 75 years, with a male predominance. Falls were the most common mode of injury. Radiological union was achieved in most patients within 6 months. The mean DASH score improved progressively from about 50 at 1 month to around 11 at 6 months, indicating good to excellent functional recovery in the majority. Complications were few and included superficial infection, screw penetration, implant loosening, and varus malunion.
Conclusion: PHILOS locking plate fixation provides stable fixation and satisfactory functional and radiological outcomes in complex proximal humerus fractures when combined with proper surgical technique and structured rehabilitation.

Keywords*: Proximal humerus fracture, PHILOS plate, Locking plate, DASH score, Functional outcome*

Introduction

Proximal humerus fractures account for approximately 4–5% of all fractures and are among the most common injuries affecting the shoulder girdle. They represent the third most common fracture pattern in elderly individuals, mainly due to age-related osteoporosis and weakening of cancellous bone in the humeral neck.[1–3] Although these fractures can occur at any age, an increasing incidence of complex fracture patterns is observed in younger patients following high-energy trauma such as road traffic accidents.[2,4,5]

The shoulder joint is a highly mobile ball-and-socket synovial joint in which a large humeral head articulates with a relatively shallow glenoid cavity. This unique anatomical configuration allows a wide range of motion but compromises

inherent stability, making fracture reduction and fixation technically demanding. Displaced three-part and four-part proximal humerus fractures often disrupt normal biomechanics. They are associated with complications such as malunion, stiffness, and avascular necrosis of the humeral head if not managed appropriately.[1,4,6]

Management of proximal humerus fractures remains controversial. Minimally displaced fractures are generally treated conservatively with satisfactory outcomes. However, displaced and multi-part fractures treated non-operatively frequently result in poor functional recovery, persistent pain, and restricted shoulder motion.[1,7,8] Various surgical options have been described, including percutaneous fixation, intramedullary nailing, hemiarthroplasty, and plate osteosynthesis, but no single modality has been universally accepted as the gold standard for complex fracture patterns.[7–9]

Locking plate systems were developed to overcome the limitations of conventional plating, particularly in osteoporotic bone. These implants provide angular stability through fixed-angle screw-plate constructs, improving fracture fixation strength, maintaining the head-shaft angle, and allowing early mobilization. Biomechanical studies have demonstrated superior stability and reduced implant loosening with locking plates compared to traditional plates and nails.[10] Clinical studies have reported favorable functional outcomes with locking plate fixation, although complication rates increase with varus malreduction, poor screw positioning, or inadequate surgical technique.[11,12]

Systematic reviews and meta-analyses have highlighted the lack of high-quality evidence and heterogeneity among published studies, making definitive treatment recommendations difficult.[9] Given the functional importance of the shoulder joint and the ongoing debate regarding optimal management, further evaluation of outcomes following locking plate fixation is warranted.[13]

Therefore, the present study was undertaken to evaluate the functional and radiological outcomes of open reduction and internal fixation using a locking plate system in patients with complex proximal humerus fractures, with functional assessment using the DASH score and serial radiographic evaluation of fracture union and alignment.[8–11]

Methods

Study Design

This was a combined prospective and retrospective observational study conducted at a tertiary care orthopaedic institute.

Study Population

Patients with proximal humerus fractures treated surgically using a PHILOS locking plate were included in the study.

Sample Size

The final analysis included 50 patients who met the inclusion criteria and completed follow- up.

Inclusion Criteria

- Three-part and four-part proximal humerus fractures
- Displaced or undisplaced fractures
- Fractures with or without shoulder dislocation
- Fractures in osteopenic or osteoporotic bone
- All age groups and both genders

Exclusion Criteria

- Patients managed conservatively
- Two-part proximal humerus fractures
- Patients unfit for anaesthesia

Initial Evaluation

All patients were assessed in the emergency department according to standard trauma protocols. Clinical details were recorded in a structured trauma sheet. Associated injuries involving the head, chest, abdomen, pelvis, and spine were evaluated. The distal neurovascular status of the affected limb was examined and documented.[14,15]

Initial immobilization was provided using an arm sling pouch. Patients were admitted to the trauma ward after stabilization.

Radiological Evaluation

Radiographic assessment was performed using Neer's trauma series, which included:

- Anteroposterior view of the shoulder
- Axillary view

Computed tomography with two- and three-dimensional reconstruction was performed in selected cases to better understand fracture morphology and support surgical planning. Fractures were classified according to Neer's classification.[7,8]

Preoperative Workup
All patients underwent routine preoperative investigations, including:

- Complete blood count
- Renal and liver function tests
- Blood grouping and cross-matching
- Electrocardiography
- Chest radiograph

Pre-anesthetic and medical fitness were obtained before surgery.
Surgical Technique Anaesthesia
Regional or general anaesthesia was administered.

Patient Positioning
Patients were positioned supine or in a beach chair position on a radiolucent table.

Surgical Approach
The surgical approach was selected based on fracture pattern and surgeon preference:

- Deltopectoral approach[1]
- Deltoid split approach[1,16]

After exposure, fracture fragments were anatomically reduced. Provisional fixation was achieved using Kirschner wires. Tuberosity fragments were secured using non-absorbable sutures. The PHILOS plate was positioned lateral to the bicipital groove, 5–8 mm distal to the greater tuberosity, and aligned with the humeral shaft. Final fixation was performed using locking screws under image intensifier guidance.[10,12]

Implant
All patients were treated with the PHILOS (Proximal Humerus Internal Locking Osteosynthesis) plate. The implant provides angular stable fixation and calcar screw support, improving stability in osteoporotic bone and reducing varus collapse.[10,12]

Postoperative Management

- Intravenous antibiotics were administered for three doses, followed by oral antibiotics
- Intravenous analgesics were given for three days, followed by oral analgesics
- Arm sling immobilization was advised

Physiotherapy Protocol

- Finger and wrist movements immediately post-surgery
- Pendulum exercises once the pain subsides
- Active assisted shoulder flexion and abduction up to 90° after 3 weeks
- External rotation and overhead abduction after 6 weeks

Weight lifting was permitted only after clinical and radiological union.

Follow Up
Patients were followed up at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months. At each visit, clinical and radiological evaluation was performed.

Outcome Assessment Functional Outcome
Functional outcome was assessed using the DASH (Disabilities of the Arm, Shoulder, and Hand) score.[17]

Radiological Outcome
Radiographs were assessed for fracture union, head shaft angle, implant position, and signs of avascular necrosis.

Definition of Union Clinical Union
Absence of pain, tenderness, and abnormal mobility at the fracture site.

Radiological Union
Obliteration of the fracture line with evidence of bridging callus.

DASH Score Interpretation

DASH score	Functional outcome
0–10	Excellent
11–30	Good
31–60	Fair
>60	Poor

Statistical Analysis
Data were entered in Microsoft Excel. Descriptive statistics were used. Continuous variables were expressed as mean and range, and categorical variables as frequency and percentage.

Ethical Approval
Approval was obtained from the Institutional Ethics Committee (Approval No. GCSMC/EC/2023/523). Written informed consent was obtained from all participants.

Results
This study included 50 patients with proximal humerus fractures treated surgically using PHILOS plating. Both prospective and retrospective cases were analyzed. All patients were followed up clinically and radiologically as per the study protocol.

The age of patients ranged from 20 to 75 years. The highest number of patients was in the 66– 75 years age group, followed by the 56–65 years age group. There were 29 male (58%) and 21 female (42%) patients, showing a male predominance.

Demographic details

Table 1: Age and gender distribution of patients (n=50)

Group	Number of patients	Percentage (%)
Age (years)		
20–24	1	2%
25–35	4	8%
36–45	4	8%
46–55	11	22%
56–65	13	26%
66–75	15	30%
>75	2	4%
Gender		
Male	29	58%
Female	21	42%
Total	**50**	**100%**

History and clinical characteristics
Falls were the most common mode of injury, followed by road traffic accidents. Right-sided fractures were more common. Only 2 patients (4%) had associated shoulder dislocation. Most patients had no related injuries. 7 patients (14%) had injuries involving other limbs or systems.

Table 3: Distribution of patients according to mode of injury, side of fracture, dislocation, and associated injuries (n=50)

Parameter and group	Number of patients	Percentage (%)
Mode of injury		
Fall	28	56%
Road traffic accident	22	44%
Side of Fracture		
Right	30	60%
Left	20	40%
Dislocation		

Present	2	4%
Absent	48	96%
Associated injury		
No associated injury	40	80%
Right acetabulum fracture	1	2%
Left base of acromion + left patella fracture	1	2%
Left proximal humerus fracture dislocation	1	2%
Right intertrochanteric femur fracture	2	4%
Right proximal humerus fracture with dislocation + left distal radius fracture	1	2%
Right medial malleolus fracture	1	2%
Total	**50**	**100%**

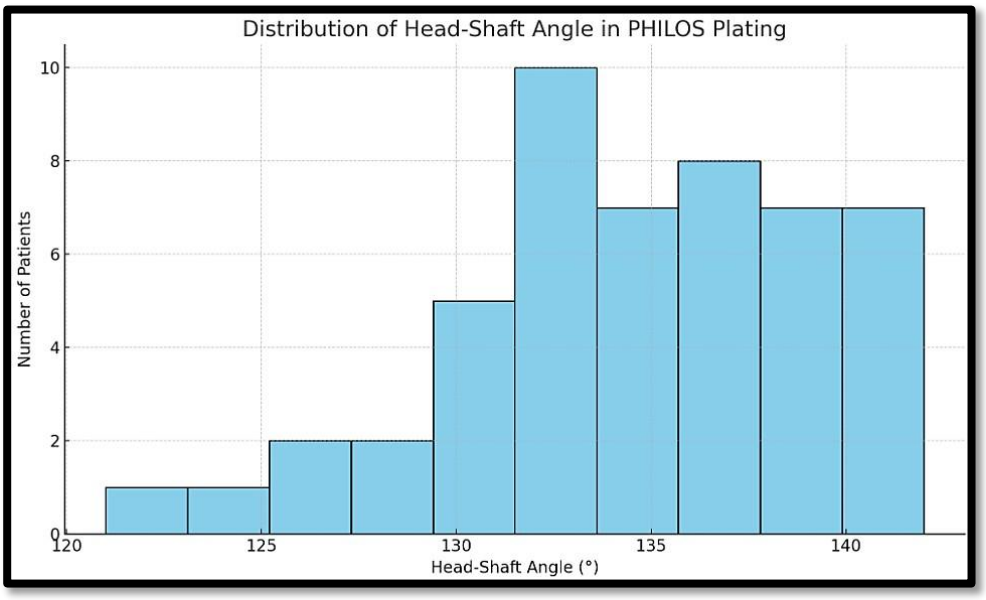
Postoperative outcomes

Complications

Postoperative complications were observed in a small number of patients. Three patients developed superficial infections, which resolved with antibiotics and regular dressing changes (two of these required delayed suture removal). One patient had screw penetration, causing pain during shoulder movements. One patient showed implant loosening without significant functional compromise. One patient developed malunion with varus fixation of the humeral head, resulting in restricted shoulder movements, particularly overhead abduction beyond 90°. One patient had a head split fracture with nonunion and was lost to follow-up.

Head–Shaft Angle

Postoperative head–shaft angles ranged from 121° to 142°. Most patients had angles between 130° and 140°, indicating satisfactory reduction.



Graph 1. Distribution of head-shaft angles following PHILOS plating

Table 7. Head–shaft angle assessment

Angle range (degrees)	Interpretation
<125°	Varus alignment
125°–142°	Acceptable alignment

Functional Outcome (DASH Score)

There was a progressive improvement in DASH scores over time.

Table 8. DASH score at different follow-up periods

Follow-up period	Mean DASH score	Functional status
1 month	~50.8	Moderate disability
3 months	~38–39	Mild to moderate disability
6 months	~11	Minimal disability

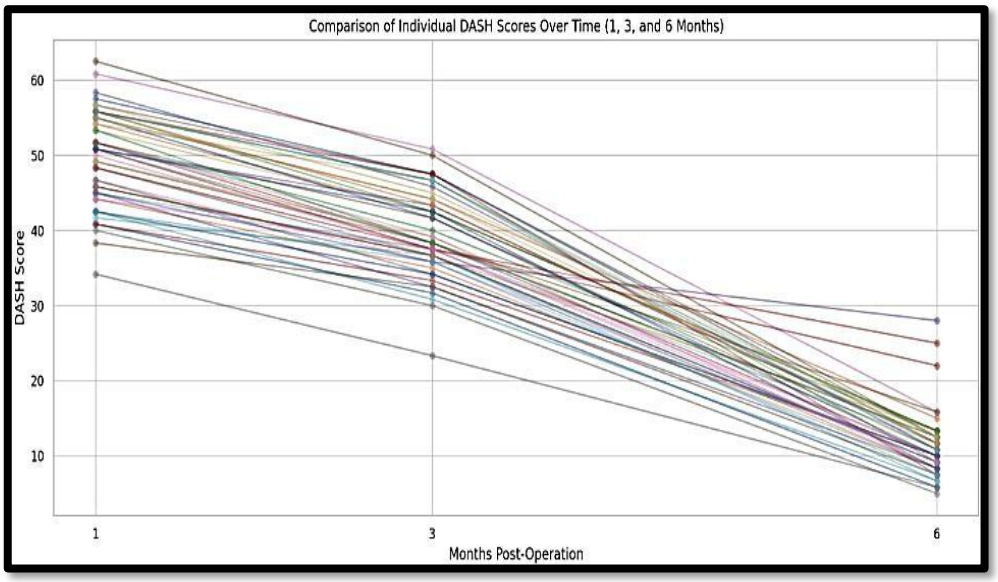


Figure 2. Individual patient recovery trends based on DASH score over time (Line graph)

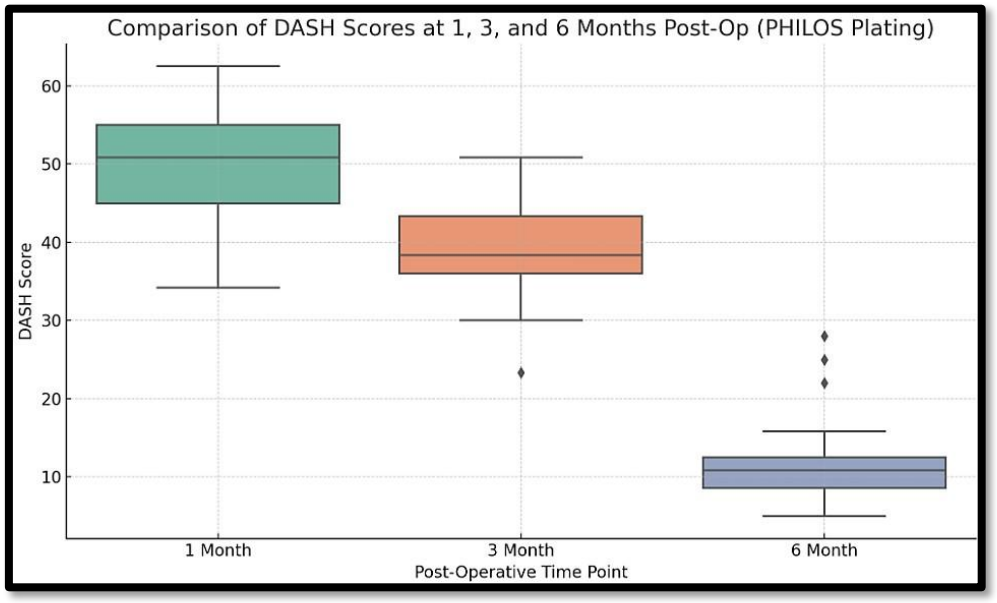


Figure 3. Boxplot showing comparison of DASH scores at 1, 3, and 6 months following PHILOS plating

At 6 months, most patients achieved good-to-excellent functional outcomes. A small number of patients had higher DASH scores due to complications such as malunion or implant-related issues.

Discussion

The present study evaluated the functional and radiological outcomes of 50 patients with complex proximal humerus fractures treated using PHILOS locking plate fixation. Functional recovery was assessed using the DASH score at 1, 3, and 6 months, and radiological outcomes were evaluated based on fracture union, alignment, and implant position.

Functional Outcomes

A progressive, statistically significant improvement in shoulder function was observed during follow-up. The mean DASH score was approximately 49.9 at 1 month, indicating significant early postoperative disability due to pain, stiffness, and limited range of motion. By 3 months, the mean score improved to approximately 39.1, reflecting the benefits of fracture healing and structured physiotherapy. At 6 months, the mean DASH score further improved to approximately 10.7, indicating near-normal upper-limb function in most patients.

These findings are consistent with previous studies demonstrating significant functional improvement following locking plate fixation of proximal humerus fractures.[10–12,18] Shahid et al. and Konrad et al. also reported good functional recovery with PHILOS plating when proper reduction and rehabilitation protocols were followed.[12,18] The gradual improvement observed in this study supports the role of stable fixation combined with early mobilization in restoring shoulder function.

Age and Fracture Pattern

Elderly patients constituted a substantial proportion of the study population. Despite osteopenia or osteoporosis, most elderly patients achieved good to excellent outcomes. The fixed-angle locking mechanism of the PHILOS plate provides angular stability independent of bone quality, making it particularly effective in osteoporotic bone.[10,12]

Younger patients, although fewer in number, were more likely to sustain high-energy trauma such as road traffic accidents. These fractures were often more displaced or comminuted. Although the final outcomes were good in most cases, complications were slightly more frequent in this group, likely attributable to the severity of injury rather than age per se. Similar observations have been reported in earlier studies.[2,4]

Fracture Configuration

Three-part fractures constituted the majority of cases and responded well to locking plate fixation, with early mobilization and satisfactory functional recovery. Four-part fractures were technically more challenging; however, with careful reduction, tuberosity fixation, and medial column support, acceptable outcomes were achieved. Neer initially reported poorer outcomes in four-part fractures, but recent literature suggests that modern fixation techniques can yield improved results.[7,8,12]

Surgical Approach

The deltopectoral approach was used in most cases, particularly in complex fracture patterns. This approach provides wide exposure and allows safe identification of anatomical landmarks, especially in fracture dislocations.[1,11] Although the deltoid split approach was also used, the deltopectoral approach was preferred in complex cases for better visualization and easier reduction.

Complications

Complications were observed in a small proportion of patients. Superficial infections were the most common and resolved with antibiotics and local wound care. Screw penetration, implant loosening, and malunion were associated with higher DASH scores and restricted shoulder motion. These complications have been well documented in prior studies and are often associated with technical factors, such as improper screw length, varus malreduction, or inadequate medial support.[11,12,19,20]

Notably, no case of avascular necrosis was observed in this study. Preservation of soft-tissue attachments and careful surgical technique likely contributed to the maintenance of humeral head vascularity, as emphasized by previous anatomical and clinical studies.[21,22]

Radiological Outcomes

Radiological union was achieved in 94% of cases within 6 months. Most patients had postoperative head-shaft angles between 126° and 142°, which are within the anatomical range reported by Einarsson and others.[23,24] Varus alignment was associated with poorer functional outcomes, supporting previous findings that restoration of medial support and head shaft angle is critical for successful outcomes.[10,12]

Role of Comorbidities and Associated Injuries

Common comorbidities such as hypertension, diabetes mellitus, ischemic heart disease, and cerebrovascular disease did not independently affect outcomes unless associated with infection or delayed rehabilitation. Patients with associated injuries experienced delayed recovery due to restricted mobilization but still achieved acceptable functional outcomes, indicating that PHILOS plating provides stable fixation even when early rehabilitation is delayed.[2,4]

Limitations

This study has several limitations. It is a Level IV case series with no control group. CT-based measurements were not routinely performed, which may have limited the precision of fracture reduction assessment. The follow-up duration was relatively short, and long-term complications such as post-traumatic arthritis and late avascular necrosis could not be evaluated. Larger randomized studies with longer follow-up are required to establish definitive treatment guidelines.

Conclusion

The present study demonstrates that open reduction and internal fixation using a PHILOS locking plate is an effective and reliable method for the management of complex proximal humerus fractures. Functional outcomes improved significantly over time, with most patients achieving good-to-excellent shoulder function by 6 months. Radiological evaluation confirmed satisfactory fracture union and maintenance of alignment in the majority of cases.

Although complications such as infection, implant-related issues, and malunion were observed in a small number of patients, these were largely manageable and often related to technical or patient-related factors. When performed with proper surgical technique, careful implant positioning, and structured rehabilitation, locking plate fixation enables early mobilization and results in favorable functional and radiological outcomes.

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Declaration of data availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to ethical and privacy considerations related to patient confidentiality.

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