

Original Research Article

Clinical and radiological outcomes of proximal humerus fracture fixation with PHILOS plate

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ABSTRACT

Background: Proximal humerus fractures account for approximately 5–6% of all adult fractures. Surgical management of displaced fractures remains challenging because of fracture complexity, poor bone quality, and the need for stable fixation. The proximal humerus internal locking system (PHILOS) plate provides angular stability and has become a widely accepted fixation method. This study evaluated the clinical and radiological outcomes of displaced proximal humerus fractures treated with PHILOS plate.

Methods: A retrospective study was conducted on 182 patients with displaced proximal humerus fractures fixed with PHILOS plate from January 2014 to December 2024. According to Neer's classification, 33 fractures were two-part, 84 were three-part, and 65 were four-part injuries. Functional outcomes were assessed using the Constant-Murley Score while radiological evaluation included fracture union, implant position, maintenance of reduction, and postoperative complications.

Results: Mean age of patients was 47.70 ± 13.96 years with mean follow-up of 21.24 ± 19.85 months. Radiological union was achieved in all patients, with a mean union time of 18.13 ± 4.62 weeks. Mean Constant-Murley Score was 74.89 ± 13.54 points. Functional outcomes were excellent in 48 patients, good in 89, fair in 25, and poor in 20 patients. Overall complication rate was 14.29%, with varus collapse being the most common complication, followed by infection, humeral head resorption, avascular necrosis, and post-traumatic arthritis.

Conclusion: PHILOS plating provided reliable fixation, fracture union, and satisfactory functional outcomes in displaced proximal humerus fractures. Restoration of medial support, accurate reduction, inferomedial calcar fixation, and structured rehabilitation are essential for optimizing outcomes and minimizing complications.

Keywords: Proximal humerus fracture, Neer classification, PHILOS, Internal fixation, Locking plate, Constant-Murley score

INTRODUCTION

Proximal humerus fractures are common injuries that continue to pose significant challenges to orthopaedic surgeons. They account for approximately 5–6% of all adult fractures and represent the third most common osteoporotic fracture after hip and distal radius fractures.^{1,2} The incidence of proximal humerus fractures has increased steadily over the last three decades, largely due to population aging and increased prevalence of osteoporosis.³ The epidemiology of proximal humerus fractures demonstrates a bimodal age distribution. Elderly

individuals usually sustain fractures following low-energy falls from standing height, whereas younger patients commonly sustain these injuries following high-energy trauma such as road traffic accidents, falls from height, and sports-related injuries.⁴ Consequently, fracture patterns, treatment requirements, and expected outcomes vary considerably among different patient populations. The anatomy of the proximal humerus contributes significantly to the complexity of fracture management. The proximal humerus consists of the humeral head, greater tuberosity, lesser tuberosity, and humeral shaft. Preservation of vascularity is particularly important because disruption of

the anterior and posterior circumflex humeral arterial systems may result in humeral head ischemia and subsequent avascular necrosis.⁵ Neer's classification remains one of the most commonly used systems for categorizing proximal humerus fractures and guiding treatment decisions.⁶ According to this classification, fractures are categorized into one-part, two-part, three-part, and four-part injuries depending on displacement of fracture fragments. Treatment options for proximal humerus fractures range from conservative management to complex reconstructive procedures. Non-operative treatment remains appropriate for minimally displaced fractures, while displaced fractures often require surgical intervention.⁷ Surgical options include percutaneous pinning, intramedullary nailing, external fixation, locking plate fixation, hemiarthroplasty, and reverse shoulder arthroplasty.⁸ Among available fixation techniques, locking plates have become increasingly popular because they provide angular stability and improved fixation in osteoporotic bone. The PHILOS plate was specifically designed to address the biomechanical challenges associated with proximal humerus fractures. Multiple locking screws directed into the humeral head create a fixed-angle construct capable of resisting varus deformity and maintaining reduction.⁹

Despite these advantages, PHILOS plating remains associated with several complications. Previous studies have reported complication rates ranging from 10% to 35%, including screw cut-out, loss of reduction, varus collapse, implant failure, infection, and osteonecrosis.^{10,11} Therefore, the present study evaluated the clinical and radiological outcomes of proximal humerus fractures treated with PHILOS plate at the institute.

METHODS

Study design

A retrospective study was conducted on 182 patients fixed with PHILOS plate for displaced proximal humerus fractures from January 2014 to December 2024 at our institute. There were 33 two-part fractures, 84 three-part fractures and 65 four-part fractures according to Neer's classification (Figure 1-3).

Inclusion criteria

It includes patient aged ≥ 18 years. Neer's two-part, three-part, and four-part fractures. Operative fixation with PHILOS plate

Exclusion criteria

Pathological fractures, open fractures, previous shoulder surgery, polytrauma patients, patients medically unfit for surgery.

Surgical technique

All patients underwent surgery in the supine position on a radiolucent operating table under fluoroscopic guidance

using a standard deltopectoral approach. After identifying the deltopectoral interval, the long head of the biceps tendon was identified and preserved as an important anatomical landmark. Heavy non-absorbable no 5 Ethibond sutures were passed through the rotator cuff tendons, including the supraspinatus, infraspinatus, and subscapularis, to facilitate manipulation and subsequent fixation of the tuberosity fragments. In patients with three-part fractures, the greater and lesser tuberosities were approximated and temporarily secured using these sutures.

Fracture reduction was achieved under direct visualization with the assistance of temporary Kirschner (K)-wires and reduction clamps to restore the humeral head to an anatomical valgus position. Particular attention was paid to maintaining the Gothic arch and restoring alignment between the inferomedial aspect of the humeral head and the medial cortex of the shaft to ensure medial column continuity and minimize the risk of varus collapse. Temporary K-wires were strategically inserted from the greater tuberosity to the humeral head, from the humeral head to the shaft, from the greater tuberosity to the shaft, and, when necessary, from the humeral head into the glenoid for temporary stabilization. Once satisfactory reduction was confirmed fluoroscopically, a PHILOS plate was positioned approximately 5-8 mm inferior to the greater tuberosity and 2-4 mm posterior to the bicipital groove. The rotator cuff sutures were passed through the designated suture holes in the plate, and an initial screw was inserted to secure the construct. A cortical screw was used in the proximal humeral shaft to draw the bone towards the plate and facilitate valgus reduction; however, when the shaft was displaced laterally, a locking screw was used instead to avoid excessive lateral displacement and maintain satisfactory alignment.

Definitive fixation was completed by inserting multiple locking screws into the humeral head, including an inferomedial calcar screw to provide medial column support and reduce the risk of varus collapse, along with appropriate cortical fixation of the humeral shaft. The tuberosity fragments were repaired and reinforced using the previously placed non-absorbable sutures. Bone grafting using autologous bone graft or a bone graft substitute was performed selectively in patients with significant metaphyseal bone defects or severe osteoporosis to improve structural support, promote fracture healing, and minimize the risk of secondary varus collapse. All temporary K-wires were removed after satisfactory definitive fixation was achieved and confirmed fluoroscopically.

Postoperative rehabilitation

All patients received standard perioperative antibiotic prophylaxis as per institutional protocol. The postoperative rehabilitation protocol emphasized early mobilization while protecting the surgical fixation. During the first six weeks after surgery, the operated limb was supported in a shoulder sling. Patients were encouraged to

perform pendulum exercises along with passive and active-assisted range-of-motion exercises as tolerated to minimize postoperative stiffness and maintain joint mobility. Between six and twelve weeks, patients progressed to active-assisted shoulder exercises, followed by active range-of-motion exercises as fracture healing permitted. After twelve weeks, progressive strengthening exercises and functional rehabilitation were initiated to restore muscle strength, shoulder stability, and activities of daily living.

Outcome measures

Radiological evaluation was performed using serial anteroposterior and axillary shoulder radiographs obtained during follow-up visits. Radiographs were assessed for evidence of fracture union, implant position, maintenance of reduction, varus collapse, osteonecrosis of the humeral head, and hardware-related complications including screw penetration or implant failure.

Functional outcomes were assessed using the constant-murley score, which evaluates pain, activities of daily living, range of motion, and shoulder strength to provide an objective assessment of postoperative shoulder function.

Complications

All intraoperative and postoperative complications were prospectively documented throughout the follow-up period. The recorded complications included superficial or deep infection, varus collapse, humeral head resorption, avascular necrosis of the humeral head, post-traumatic glenohumeral arthritis, implant-related complications, and any requirement for revision surgery.

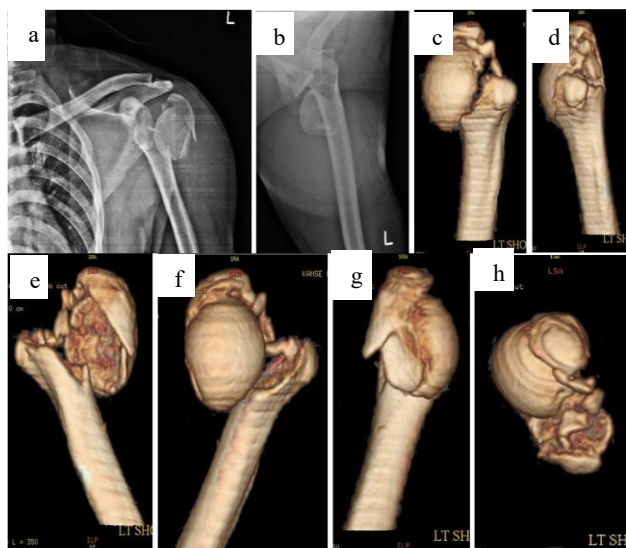


Figure 1 (a-h): Preoperative X-rays and CT scan of a 40-year-old male with left 4-part proximal humerus fracture.

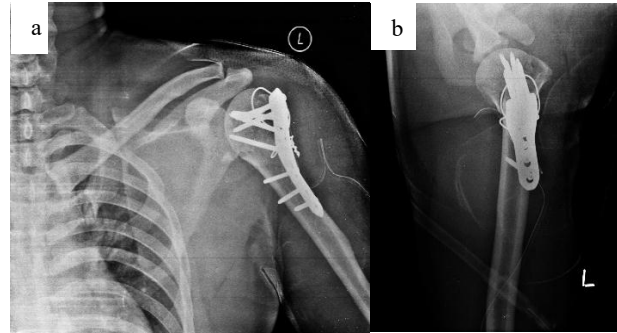


Figure 2 (a, b): Postoperative X-rays of a 40-year-old male with left 4-part proximal humerus fracture.

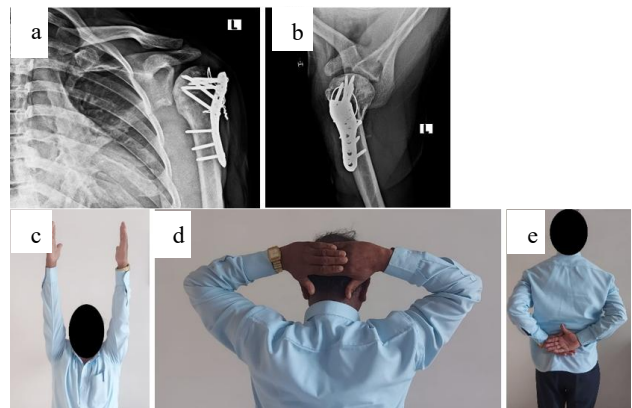


Figure 3 (a-e): 8 years follow-up X-rays and clinical photos of a 40-year-old male with left 4-part proximal humerus fracture.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±standard deviation (SD) whereas categorical variables were presented as frequencies and percentages.

RESULTS

A total of 182 patients with displaced proximal humerus fractures who underwent open reduction and internal fixation using the PHILOS plate were included in the study. The mean age of the study population was 47.70 ± 13.96 years (range, 18–89 years). There were 121 males (66.48%) and 61 females (33.52%), demonstrating a male predominance. The right shoulder was affected in 110 patients (60.44%), whereas 72 patients (39.56%) sustained left-sided injuries. According to Neer's classification, 33 patients (18.13%) sustained two-part fractures, 84 patients (46.15%) had three-part fractures, and 65 patients (35.71%) presented with four-part fractures. Three-part fractures were the most common fracture pattern.

Radiological union was achieved in all patients, with a mean union time of 18.13 ± 4.62 weeks (range, 12–24

weeks). The mean follow-up duration was 21.24±19.85 months (range, 12–106 months), allowing adequate assessment of fracture healing, implant stability, functional recovery, and late complications. Functional outcome was evaluated using the Constant-Murley Score. The mean Constant-Murley Score was 74.89±13.54 points, indicating overall satisfactory shoulder function. Based on the Constant-Murley Score grading system, 48 patients (26.37%) achieved excellent outcomes, 89 patients (48.90%) achieved good outcomes, 25 patients (13.74%) had fair outcomes, and 20 patients (10.99%) had poor outcomes. Overall, 137 patients (75.27%) achieved good-to-excellent functional outcomes, while 162 patients (89.02%) achieved at least a fair functional outcome. The overall complication rate was 14.29%. Varus collapse was the most frequently encountered complication, occurring in 11 patients (6.05%). Superficial or deep surgical-site infection developed in 7 patients (3.85%). Among these,

three patients responded successfully to antibiotic therapy alone, three patients required surgical debridement, and one patient underwent implant removal following debridement because of persistent infection and was subsequently revised with a multilock intramedullary nail after infection control. Humeral head resorption was observed in 4 patients (2.20%), avascular necrosis developed in 3 patients (1.65%), and post-traumatic glenohumeral arthritis occurred in 1 patient (0.55%) during follow-up. No cases of implant breakage or screw pull-out requiring revision surgery were observed. Fracture union was achieved in all patients despite the occurrence of these complications. Representative clinical, demographic, radiological, and functional outcome data are summarized in Table 1, which outlines patient demographics, fracture characteristics, union time, functional outcomes, and postoperative complications.

Table 1: Various parameters with respect to proximal humerus fracture fixation.

Parameters	No of cases (n=182)	Percentage
No. of patients	Male	121
	Female	61
Age (in years)	Mean±SD	47.70±13.96
	18-30	21
	31-50	88
	51-75	68
	75-89	05
Proximal humerus fracture	Right	110
	Left	72
Neer classification	2-part	33
	3-part	84
	4-part	65
Radiographic union	Mean±SD	18.13±4.62
Follow up	Mean±SD	21.24±19.85
Constant-Murley score	Mean±SD	74.89±13.54
	Excellent (86-100)	48
	Good (71-85)	89
	Fair (56-70)	25
	Poor (0-55)	20
Complications	Varus collapse	11
	Infection	7
	Humeral head resorption	4
	Avascular necrosis	3
	Arthritis	1

DISCUSSION

The management of displaced proximal humerus fractures remains controversial despite significant advances in surgical implants and fixation techniques. The ideal treatment should restore anatomy, preserve vascularity, provide stable fixation, and facilitate early mobilization while minimizing complications. The mean age of 47.7 years observed in this study differs from many Western series, where reported mean ages generally exceed 60 years.^{12,13} Südkamp et al reported a mean age of 63 years, while Solberg et al reported a mean age of 65 years.^{12,13}

This difference likely reflects regional variations in injury mechanisms. In developing countries, road traffic accidents and occupational injuries contribute substantially to proximal humerus fractures in younger adults. The male predominance observed in our cohort similarly reflects greater exposure to high-energy trauma. Three-part fractures represented nearly half of all injuries. This finding is consistent with the reports of Agudelo et al and Moonot et al who also identified three-part fractures as the most common surgically treated fracture pattern.^{14,15} The substantial proportion of four-part fractures in our series highlights the complexity of the patient population.

These fractures have traditionally been associated with poorer outcomes because of extensive vascular disruption and an increased risk of osteonecrosis.¹⁶ The success of PHILOS fixation is based on the biomechanical principles of angular stability. Unlike conventional plating systems, locking plates create a fixed-angle construct that functions as an internal fixator, reducing dependence on bone quality and minimizing screw loosening.¹⁷ Bone graft augmentation was used selectively in patients with severe metaphyseal defects or osteoporotic bone to improve construct stability. Biomechanical studies by Liew et al demonstrated significantly greater resistance to displacement with locking plates than with conventional fixation methods, while Brianza et al reported superior construct stiffness and load-sharing characteristics.^{18,19} These biomechanical advantages are particularly important in osteoporotic bone, where conventional fixation is more prone to failure. Restoration of medial support has emerged as one of the most important determinants of successful fixation. Gardner et al demonstrated that disruption of the medial calcar significantly increases the risk of fixation failure and varus collapse.²⁰ The inferomedial calcar acts as a critical buttress against compressive forces across the proximal humerus. Subsequent studies have confirmed that inferomedial calcar screws, restoration of the medial hinge, and selective bone graft augmentation substantially improve construct stability and reduce fixation failure, particularly in osteoporotic fractures.²¹ These principles were routinely applied in the present series and may have contributed to the favourable radiological and functional outcomes.

The mean Constant-Murley score in the present study was 74.89 at a mean follow-up of 21.24 months, which was comparable with previously published PHILOS series. Gerber et al reported a mean Constant score of 78 at a mean follow-up of 63 months, whereas Brunner et al, Südkamp et al, Agudelo et al, and Moonot et al reported mean scores of approximately 72, 72.4, 73–75, and 76.8, respectively, at approximately 12 months after surgery.^{5,9,12,14,15,22} These findings support the effectiveness of PHILOS plating when anatomical reduction, stable fixation, and structured postoperative rehabilitation are achieved. Likewise, Schumaier et al and Grawe et al concluded that PHILOS fixation provides predictable functional recovery when satisfactory fracture reduction is obtained, with early rehabilitation remaining a key determinant of postoperative shoulder function.

The high union rate observed in the study is consistent with published literature, where union rates following PHILOS fixation generally range from 90% to 98%.^{12,14} Successful fracture healing depends on preservation of the blood supply, stable fixation, restoration of alignment, and early controlled mobilization. Locking plate constructs facilitate these objectives while minimizing additional soft-tissue disruption. Varus collapse occurred in 6.05% of patients and was the most common complication, consistent with

previous reports identifying varus malalignment as the principal mechanism of fixation failure.^{20,24} Contributing factors include osteoporosis, medial comminution, inadequate reduction, improper plate positioning, and failure to restore inferomedial support. Contemporary fixation techniques therefore emphasize restoration of the neck-shaft angle, strategic placement of inferomedial calcar screws, and selective bone graft augmentation to minimize this complication. Infection occurred in 3.85% of patients, which falls within the reported incidence of 1%–5% following proximal humerus fixation.¹⁰

Strict adherence to aseptic surgical technique, meticulous soft-tissue handling, and appropriate perioperative antibiotic prophylaxis remain essential for minimizing postoperative infection. Avascular necrosis developed in only three patients (1.65%). Hertel et al identified disruption of the posteromedial hinge and a short metaphyseal extension as major predictors of humeral head ischemia. Published rates of avascular necrosis following locking plate fixation range from 4% to 16%, particularly in four-part fractures.²²

The relatively low incidence observed in the present study may reflect careful preservation of soft tissues and meticulous fracture reduction. Humeral head resorption occurred in four patients, while greater tuberosity resorption was observed in one patient. These complications likely reflect severe initial vascular injury and may represent part of the spectrum of osteonecrotic changes. Gerber et al emphasized the importance of preserving the remaining vascular supply to maintain humeral head viability.⁵

In recent years, reverse shoulder arthroplasty (RSA) has gained increasing acceptance for the management of complex proximal humerus fractures in elderly patients because it provides reliable pain relief and early functional recovery.²⁵ However, fracture fixation remains the preferred treatment for younger and active patients with reconstructible fracture patterns and preserved humeral head vascularity. Fraser et al reported superior forward elevation with RSA but also highlighted its higher cost and prosthesis-related complications.²⁵ Consequently, PHILOS plating continues to play an important role in the management of displaced proximal humerus fractures in appropriately selected patients.

Limitations

Retrospective design, single-centre study, absence of a comparison group.

CONCLUSION

In this retrospective cohort, PHILOS plating was associated with reliable fracture union and satisfactory functional outcomes in displaced proximal humerus fractures. Meticulous surgical technique, accurate fracture

reduction, inferomedial calcar fixation, and structured rehabilitation are key determinants of successful clinical outcomes. Despite the increasing use of reverse shoulder arthroplasty for complex proximal humerus fractures in elderly patients, PHILOS plating continues to provide excellent results in appropriately selected patients, particularly younger individuals with reconstructible fracture patterns.

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

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