International Journal of Research in Orthopaedics
Elias V et al. Int J Res Orthop. 2026 Mar;12(2):395-400
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20260505

Functional outcomes of proximal humerus internal locking system plating with tension suture fixation for proximal humerus fractures: a prospective study

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Received: 05 February 2026
Accepted: 20 February 2026

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ABSTRACT

Background: Proximal humerus fractures are increasingly common injuries, particularly among the elderly osteoporotic population. While the majority of these fractures are undisplaced and can be managed conservatively, displaced fractures often require surgical intervention to restore anatomical alignment and function. The proximal humerus internal locking system (PHILOS) has become a standard implant for these injuries, but outcomes can vary. This study evaluates the functional outcomes of displaced proximal humerus fractures treated with PHILOS plating augmented by tension suture fixation.
Methods: A prospective study was conducted on 30 patients with displaced proximal humerus fractures between September 2020 and August 2022 at a tertiary care centre. Patients underwent open reduction and internal fixation through a deltopectoral approach under fluoroscopic guidance. The surgical technique involved the use of a PHILOS plate combined with tension sutures to stabilise the tuberosities and neutralise the deforming forces of the rotator cuff. Functional outcomes were assessed using the Constant-Murley Score after at least 6 months of follow-up.
Results: The mean age of the study population was 53 years, with a female preponderance (73.3%). The most common injury pattern was Neer's 3-part fracture (43.3%). The mean Constant Score at the final follow-up was 77.4. Excellent or good functional outcomes were achieved in 83.3% of patients (7 excellent, 18 good). Complications were minimal, with superficial wound infection in 10% of cases and shoulder stiffness in 3.3%.
Conclusions: The combination of PHILOS plating and tension suture fixation provides rigid, stable fixation and allows for early mobilisation. This technique effectively restores the anatomy of the articular surface and the tuberosities, yielding satisfactory functional outcome with a low complication rate, making it a reliable treatment option for displaced proximal humerus fractures in the elderly.

Keywords: Proximal humerus fracture, PHILOS plate, Tension suture, Constant score, Functional outcome

INTRODUCTION

Proximal humerus fractures are among the most common orthopaedic injuries, accounting for approximately 4-5% of all fractures and 45% of all humeral fractures,76% of humeral fractures in adults over 40 years.[1] They are the third most common fractures in the elderly population, following hip and distal radius fractures, with an incidence that is rising due to the ageing population and the prevalence of osteoporosis.[2] While the majority of these fractures are non-displaced or minimally displaced and can be managed conservatively, approximately 15% to 20% are displaced and unstable, necessitating surgical intervention to restore anatomical alignment and maximise functional recovery.

The management of displaced proximal humerus fractures remains a subject of debate.[3] Conservative management in displaced cases is often associated with complications such as malunion, nonunion, and stiffness, leading to poor functional outcomes.[4,5] Conversely, surgical fixation in osteoporotic bone presents significant challenges, primarily related to screw cutout, varus collapse, and implant failure.[6] The introduction of the proximal humerus internal locking system (PHILOS) has revolutionised treatment. Designed to provide angular stability, the PHILOS plate reduces the risk of implant failure in osteopenic bone compared to conventional plating. It allows for early mobilisation, crucial for preventing adhesive capsulitis and ensuring a good range of motion.[7]

Despite the advantages of locking plates, complications remain a concern. Recent systematic reviews indicate that intra-articular screw penetration and varus collapse are among the most reported complications following locking plate fixation.[8] A critical factor in preventing these failures is the stability of the tuberosities. The displacement of the greater and lesser tuberosities is driven by the deforming forces of the rotator cuff: the supraspinatus and infraspinatus pull the greater tuberosity superiorly and posteriorly, while the subscapularis pulls the lesser tuberosity medially. Failure to neutralise these forces can lead to tuberosity escape, malunion, and loss of the rotator cuff force couple, severely compromising shoulder function.

To address this, the augmentation of locking plate fixation with tension sutures has emerged as a vital technique.[9] Securing the rotator cuff tendons to the plate via suture holes neutralises the displacing muscle forces and acts as a tension band, enhancing the stability of the construct.[10,11] This "hybrid" fixation strategy—combining the rigid angular stability of the PHILOS plate with the biological fixation provided by tension sutures—aims to minimise implant failure and optimise functional outcomes.

While several studies have evaluated the PHILOS plate, there is a need for prospective data focusing specifically on the functional outcomes of this combined fixation technique in displaced fractures. The present study aims to prospectively evaluate functional outcomes, radiographic union, and complication rates in proximal humerus fractures treated with PHILOS plating and tension-suture fixation.

METHODS

Study design and setting

This prospective study was conducted at the Department of Orthopaedics, Iqraa International Hospital and Research Centre, Kozhikode, Kerala. The study spanned 2 years. Ethical clearance was obtained from the Institutional Ethics Committee prior to the commencement of the study.

Participants

A total of 30 patients admitted with proximal humerus fractures requiring operative intervention were recruited for the study. Informed written consent was obtained from all participants.

Inclusion criteria

Age >18 years, closed or Gustilo Anderson type I open displaced Neer's 2-, 3-, or 4-part proximal humerus fractures were included.

Exclusion criteria

Pathological/metastatic fractures; ipsilateral upper limb major fractures; neurovascular deficits; non-consenting patients were excluded.

Preoperative assessment

Upon admission, all patients underwent a detailed clinical history and physical examination to rule out associated injuries and assess distal neurovascular status. Radiographic evaluation included standard trauma series X-rays: anteroposterior (AP), lateral, and axillary views. Computed tomography (CT) scans were utilised in selected cases with complex fracture patterns to accurately assess articular involvement. Routine preoperative investigations and anaesthetic fitness were obtained for all patients.

Surgical technique

All surgeries were performed under combined general anaesthesia and interscalene block.

Positioning: Patients were positioned supine with a sandbag placed between the spine and the medial border of the scapula to elevate the affected side.

Approach: A standard deltopectoral approach was utilised for all cases.

Fixation: Fracture fragments were reduced indirectly and temporarily stabilised with K-wires under image intensifier guidance. A critical step involved the identification of the rotator cuff tendons; horizontal tension sutures were placed to reduce and stabilise the tuberosity fragments, countering the deforming pull of the supraspinatus and subscapularis muscles.

Implant placement: The PHILOS plate was positioned lateral to the bicipital groove (preserving the long head of the biceps) and at least 8 mm distal to the superior aspect of the greater tuberosity. Locking head screws were inserted into the humeral head and shaft to achieve rigid fixation. The final construct was verified using an image intensifier in multiple planes.

Postoperative management

Intravenous antibiotics were continued until the third postoperative day. Sutures were removed on the 12th postoperative day. Immediate postoperative X-rays were taken to document reduction and fixation. Sling immobilisation was done for 3 weeks, allowing pendulum exercises from day 1, active-assisted by week 2, and full ROM by 6 weeks. Radiographic follow-up was performed at 3- to 4-week intervals to monitor fracture union and assess for implant-related complications, such as loosening or screw penetration (Figure 1 and 2).

Figure 1: 55-year-old male with Neer's 3-part fracture of the right proximal humerus. (A and B) Preoperative radiograph; (C) Immediate Postoperative radiograph; (D) 6 months follow-up radiograph; (E-H) Range of motion at 6 months follow-up.

Figure 2: 50-year-old male with Neer's 2-part fracture of the right proximal humerus. (A and B) Preoperative radiograph and NCCT; (C) Immediate postoperative radiograph; (D) 6 months follow-up radiograph; (E-H) Range of motion at 6 months follow-up.

Outcome assessment and statistical analysis

Functional outcome was assessed using the Constant-Murley Score. Pain levels were evaluated during follow-up visits. Data were coded and entered into Microsoft Excel, and statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) software. A master chart was prepared to categorise outcomes based on fracture type, age, and complications.

RESULTS

Demographic and clinical characteristics

The study included 30 patients with displaced proximal humerus fractures. The participants' ages ranged from 28 to 74 years, with a mean of 53 years. The majority of patients (60%) were in the 41–60 year age group. There was a female preponderance, with 22 female patients (73.3%) and 8 male patients (26.7%), resulting in a male-to-female ratio of 1:2.75.

Mechanism of injury and fracture classification

Road traffic accidents (RTAs) were the most common cause of injury, accounting for 53.3% (n=16) of cases, followed by falls at 43.3% (n=13) and assault at 3.3% (n=1).

Fractures were classified according to Neer's classification system. The most frequent pattern observed was the 3-part fracture, seen in 13 patients (43.3%). 2-part fractures were present in 9 patients (30%), while 4-part fractures were observed in 8 patients (26.7%).

Union

All achieved union by 12 weeks (mean 10.4 weeks), without varus collapse or screw cutout.

Functional outcomes

Functional assessment was performed using the Constant-Murley Score at the final follow-up. The mean Constant Score for the entire study population was 77.4 (range 42–92).

Excellent outcome (Score 86-100): Achieved in 7 patients (23.3%). Good outcome (Score 70-85): Achieved in 18 patients (60%). Moderate outcome (Score 55-70): Observed in 3 patients (10%). Poor outcome (Score 0-55): Observed in 2 patients (6.7%). Statistical analysis revealed a significant association between the fracture type and the functional outcome (p=0.000). Patients with 2-part fractures had the highest mean Constant Score (87.44), followed by 3-part fractures (79.31), while those with 4-part fractures had significantly lower scores (63.00).

Pain assessment

At the 6-month follow-up, the majority of patients reported satisfactory pain relief.

No pain: 18 patients (60%). Mild pain: 11 patients (36.7%). Moderate pain: 1 patient (3.3%). There was a statistically significant correlation between pain scores and the final Constant Score (p=0.000).

Complications

The overall complication rate was low. Postoperative complications were noted in 4 patients (13.3%):

Superficial wound infection: Occurred in 3 patients (10%), all of whom were older and diabetic. Shoulder stiffness: Observed in 1 patient (3.3%). The presence of complications was significantly associated with lower functional outcomes (p=0.005). No cases of implant failure, screw back-out, or non-union were recorded in this series.

Table 1: Demographic profile, fracture characteristics, and functional outcomes of the study population.

Parameter	Category / Statistic	Value (N)	Percentage / Mean
Demographics	Mean age	-	53 years (Range: 28-74)
	Gender distribution	Female: 22; Male: 8	73.3 26.7
Mechanism of injury	Road traffic accident (RTA)	16	53.30
	Fall from height/ground	13	43.30
	Assault	1	3.30
Fracture type (Neer's)	2-part fracture	9	30.00
	3-part fracture	13	43.30
	4-part fracture	8	26.70
Functional outcome (Constant-Murley score)	Mean constant score	-	77.4
	Excellent (86-100)	7	23.30
	Good (70-85)	18	60.00
	Moderate (55-70)	3	10.00
	Poor (0-55)	2	6.70
Pain assessment (At 6-month follow-up)	No pain	18	60.00
	Mild pain	11	36.70
	Moderate pain	1	3.30
Complications	None	26	86.70
	Superficial wound infection	3	10.00
	Shoulder stiffness	1	3.30%

Table 2: Functional outcomes and complications by Neer's fracture type.

Fracture type (N)	Mean constant score	Excellent/good (%)	Complications (N)
2-part (9)	87.4±4.2	100	0
3-part (13)	79.3±5.1	92.3	2 (infection)
4-part (8)	63.0±8.3	50	2 (infection, stiffness)
Overall (30)	77.4±9.6	83.3	4

DISCUSSION

The management of displaced proximal humerus fractures remains a complex challenge in orthopaedic surgery, particularly in osteoporotic bone, where screw purchase can be compromised. The primary goal of surgical intervention is to achieve anatomical reduction and stable fixation that permits early functional rehabilitation. This prospective study evaluated the functional outcomes of 30 patients treated with the Proximal Humerus Internal Locking System (PHILOS) augmented with tension suture fixation.

The demographic profile of our study population revealed a mean age of 53 years, which is slightly younger than the average age reported in some Western literature (typically >60 years). This variance may be attributed to the high incidence of high-energy trauma, such as road traffic accidents (53.3%), observed in our series. Consistent with global epidemiological data, we observed a female preponderance (73.3%), likely reflecting the higher prevalence of osteoporosis in postmenopausal women.[12] The fracture distribution in our series, with Neer's 3-part fractures being the most common (43.3%), aligns with findings by Fazal et al and Rizwan et al, who also reported a high prevalence of 3-part fractures in surgical candidates.[13,14]

The functional outcome, assessed using the Constant-Murley Score (CMS), showed a mean score of 77.4 at the final follow-up. This is comparable to the results reported by Zingg et al.15 (mean CMS 77.1) and slightly lower than those reported by Jiang et al.16 (mean CMS 88.2). We achieved excellent or good outcomes in 83.3% of patients. These favourable results underscore the efficacy of the PHILOS plate in providing angular stability, which prevents the secondary varus collapse often seen with conventional non-locking plates.

A critical component of our surgical technique was the use of tension sutures to secure the tuberosities. The deforming forces of the rotator cuff—supraspinatus pulling the greater tuberosity superiorly and posteriorly, and subscapularis pulling the lesser tuberosity medially—are significant causes of fixation failure. By incorporating tension sutures through the rotator cuff tendons and securing them to the plate, we neutralised these distracting forces.[17] This "hybrid" fixation acts as a tension band, converting distracting tensile forces into compressive forces, thereby enhancing the construct's stability. Recent biomechanical studies have supported this approach, demonstrating that suture augmentation significantly increases the load to failure in proximal humerus fracture models.[10]

Our complication rate was relatively low at 13.3%. We observed superficial wound infection in 10% of cases; all were diabetic and managed with antibiotics. Notably, we did not observe cases of avascular necrosis (AVN) or screw cutout in our series, complications that are frequently reported in the literature.[18,19] This may be attributed to our adherence to meticulous soft-tissue handling, preservation of the bicipital groove vascularity, and the use of the tension suture technique, which reduces reliance on screw purchase alone in osteopenic tuberosities.[20,21] Only one patient developed shoulder stiffness, emphasising the importance of aggressive postoperative physiotherapy.

While the PROFHER trial suggested no significant difference between surgical and non-surgical management for the general population.[22,23] Our study specifically targeted displaced fractures where reduction is critical for function. Our data support the view that in active patients with displaced 3-part and 4-part fractures, surgical restoration of anatomy leads to predictable functional recovery, avoiding the malunion and dysfunction often associated with conservative neglect.[24]

Strengths of our study include a prospective design, a uniform technique, and validated scoring. The limitations include the relatively small sample size (n=30) and the lack of a control group treated with conservative management or alternative implants. Future randomised controlled trials with larger cohorts and longer follow-up periods are recommended to validate these findings further.

CONCLUSION

The combination of PHILOS plating and tension suture fixation provides a mechanically robust construct that addresses both the osseous and soft-tissue components of proximal humerus fractures. This technique allows for early mobilisation and yields satisfactory functional outcomes, making it a reliable treatment option for displaced fractures in the adult population.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Elias V, Patro DR, Thazhathodi U. Functional outcomes of proximal humerus internal locking system plating with tension suture fixation for proximal humerus fractures: a prospective study. Int J Res Orthop 2026;12:395-400.