



Original Article

Clinical Outcomes of Neer 3 and 4 Part Fractures of Proximal Humerus in Elderly Treated by Locking Plate and Screws with Augmentation Using Fibular Strut Autograft: A Prospective Clinical Study

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ABSTRACT

Background: Proximal humerus fractures, particularly Neer 3- and 4-part fractures, are common in the elderly and are associated with poor bone quality, instability, and high complication rates. Locking plate fixation using PHILOS plates has improved outcomes; however, medial column deficiency often leads to varus collapse and fixation failure. Augmentation with fibular strut autograft has been proposed to enhance stability and improve functional outcomes.

Aim: To evaluate the clinical, functional, and radiological outcomes of Neer 3- and 4-part proximal humerus fractures in elderly patients treated with locking plate fixation augmented with fibular strut autograft.

Materials and Methods: This prospective clinical study was conducted in the Department of Orthopaedics at Shri B.M. Patil Medical College, Vijayapura, over 18 months (March 2024–December 2025). A total of 23 patients aged 50–75 years with Neer type 3 and 4 proximal humerus fractures were included. All patients underwent open reduction and internal fixation using PHILOS plate with fibular strut autograft augmentation. Patients were followed up at 6 weeks, 3 months, and 6 months. Functional outcomes were assessed using DASH and Constant-Murley scores, while radiological union and complications were recorded. Statistical analysis was performed using SPSS version 20, with $p < 0.05$ considered significant.

Results: The majority of patients were in the 61–70 years age group, with a slight female predominance. The mean operative time was 98.22 ± 7.78 minutes. Significant improvement was observed in pain and range of motion over time ($p < 0.001$). The mean time to union was 7.83 ± 2.17 months. Complications were minimal, with infection and screw perforation observed in one patient each (8.7%). Functional outcomes were excellent in 47.8%, good in 39.1%, fair in 8.7%, and poor in 4.3% of patients.

Conclusion: Locking plate fixation augmented with fibular strut autograft is an effective and reliable technique for managing Neer 3- and 4-part proximal humerus fractures in elderly patients. It provides enhanced medial support, promotes fracture union, and results in good functional outcomes with a low complication rate.

Keywords: Proximal humerus fracture, Neer classification, PHILOS plate, fibular strut autograft, elderly, functional outcome.

INTRODUCTION

Proximal humerus fractures are common injuries, particularly in the elderly population, accounting for approximately 4–6% of all fractures and representing the third most common osteoporotic fracture after hip and distal radius fractures [1]. The incidence is increasing due to aging populations and osteoporosis, with most injuries resulting from low-energy falls [2].

The **Neer classification system** is widely used to categorize these fractures based on the number of displaced segments, with 3- and 4-part fractures representing more complex injury patterns associated with disruption of blood supply, instability, and a higher risk of complications such as malunion and avascular necrosis [3].

Management of these fractures remains controversial. While conservative treatment may be adequate for minimally displaced fractures, displaced 3- and 4-part fractures often require surgical intervention to restore anatomy and function [4]. Open reduction and internal fixation (ORIF) using locking plates, particularly the **Proximal Humerus Internal Locking System (PHILOS)**, has gained popularity due to its biomechanical advantage in osteoporotic bone [5]. However, complications such as varus collapse, screw cut-out, and fixation failure remain concerns, especially in cases with medial column comminution [6].

To address these challenges, augmentation techniques such as the use of a **fibular strut autograft** have been introduced. The fibular graft provides medial structural support, enhances stability, and helps maintain the neck-shaft angle, thereby reducing the risk of varus collapse and implant failure [7]. Several studies have demonstrated improved functional and radiological outcomes with this technique in elderly patients with osteoporotic bone [8].

Despite advancements in surgical techniques, there is still limited prospective data evaluating the clinical outcomes of PHILOS plate fixation augmented with fibular strut grafts in Neer 3- and 4-part fractures. Therefore, this study was undertaken to assess the functional and radiological outcomes of this combined approach in elderly patients.

MATERIALS AND METHODS

Study Design and Setting

This prospective clinical study was conducted in the Department of Orthopaedics at B.L.D.E. (Deemed to be University), Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapura, Karnataka, India, over a period of 18 months from March 2024 to December 2025.

Study Population and Sample Size

The study included patients presenting with proximal humerus fractures. The sample size was calculated based on a previous study by Sameer Panchal et al., considering a mean neck-shaft angle with a standard deviation of 2.5, a confidence level of 99% ($Z = 2.58$), and a margin of error of 1.5.

The sample size was calculated using the formula:

$$n = (Z \times \sigma / d)^2$$

Based on this calculation, the estimated sample size was 23 patients. Accordingly, 23 patients fulfilling the inclusion criteria were enrolled in the study.

Inclusion Criteria

Patients aged between 50 and 75 years, Clinically and radiologically confirmed Neer type 3 and 4 part proximal humerus fractures, Fractures associated with medial comminution and varus collapse, Patients willing to participate and provide informed consent, Patients deemed fit for surgery after pre-anaesthetic evaluation

Exclusion Criteria

Age < 50 years, Previous surgery on the affected shoulder, Severe glenohumeral osteoarthritis, Pre-existing shoulder stiffness, Delayed presentation (>4 weeks after injury), Open fractures, Pathological fractures, Associated neurovascular injury, Medically unfit patients, Patients unwilling to participate.

Method of Data Collection

Patients presenting with proximal humerus fractures were clinically evaluated and subjected to radiological investigations. Those meeting the inclusion criteria were enrolled after obtaining informed written consent. Detailed demographic data, mechanism of injury, comorbidities, and clinical findings were recorded using a predesigned proforma.

Pre-operative Evaluation

All patients underwent thorough clinical and radiological assessment. Standard anteroposterior and lateral radiographs of the shoulder were obtained. Computed tomography with three-dimensional reconstruction was performed in selected cases for better fracture delineation.

Routine preoperative investigations included complete blood count, renal and liver function tests, blood sugar levels, coagulation profile, ECG, chest radiograph, and echocardiography where indicated. Pre-anaesthetic clearance was obtained prior to surgery.

Surgical Technique

All procedures were performed under general anaesthesia with the patient in the beach-chair position using a standard deltopectoral approach. Fracture fragments were anatomically reduced and temporarily fixed with Kirschner wires. A fibular strut autograft was harvested and inserted into the medullary canal to provide medial support. Definitive fixation was done with a PHILOS plate, with locking screws placed in the humeral head and shaft, some engaging the graft. Tuberosities were secured using non-absorbable sutures through rotator cuff insertions.

Post-operative Management

Patients received appropriate antibiotics and analgesics postoperatively. Early mobilization of the hand and wrist was encouraged from the first postoperative day.

- Passive pendulum exercises: 3–5 days postoperatively
- Active-assisted exercises: after 2 weeks
- Active range of motion: after 6 weeks
- Strengthening exercises: after radiological union (~3 months)

Sutures were removed on postoperative days 10–12. Patients were advised to avoid heavy lifting until complete fracture healing.

Follow-up Protocol

Patients were followed up at 6 weeks, 3 months, and 6 months postoperatively. Each follow-up included clinical and radiological evaluation.

Radiographic union was defined as bridging callus across at least three cortices on orthogonal views, along with absence of tenderness at the fracture site.

Outcome Assessment

Functional outcomes were assessed using:

- Disabilities of the Arm, Shoulder and Hand (DASH) score
- Constant-Murley Score (CMS)

Range of motion was measured using a goniometer, and muscle strength was assessed using a dynamometer.

Radiological parameters assessed included neck-shaft angle, humeral head height, and implant position. Complications such as screw penetration, varus collapse, avascular necrosis, non-union, and implant failure were recorded.

Statistical Analysis;

Data were analyzed using SPSS v20. Continuous variables were expressed as mean \pm SD and categorical variables as frequency (%). Independent t-test/Mann–Whitney U test, Chi-square/Fisher’s exact test, and ANOVA/Kruskal–Wallis test were applied as appropriate. A p-value < 0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS

The present prospective clinical study included 23 patients with Neer 3- and 4-part proximal humerus fractures treated with locking plate fixation augmented with fibular strut autograft. The study evaluated demographic characteristics along with clinical, functional, and radiological outcomes.

Demographic Profile

Table 1: Demographic Characteristics of Study Population (N = 23)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	50–60 years	9	39.1%
	61–70 years	13	56.5%
	>70 years	1	4.3%
Sex	Female	12	52.2%
	Male	11	47.8%
Total	—	23	100%

Surgical Details

Table 2: Operative Parameters and Graft Characteristics (N = 23)

Variable	Category / Parameter	Frequency (n)	Percentage (%)	Mean ± SD
Surgery Duration	—	—	—	98.22 ± 7.78 min
Fibular Graft Length	6 cm	12	52.2%	—
	7 cm	6	26.1%	—
	8 cm	5	21.7%	—
Total	—	23	100%	—

The mean duration of surgery was 98.22 ± 7.78 minutes, indicating a relatively consistent operative time across all cases with minimal variation, reflecting procedural standardization.

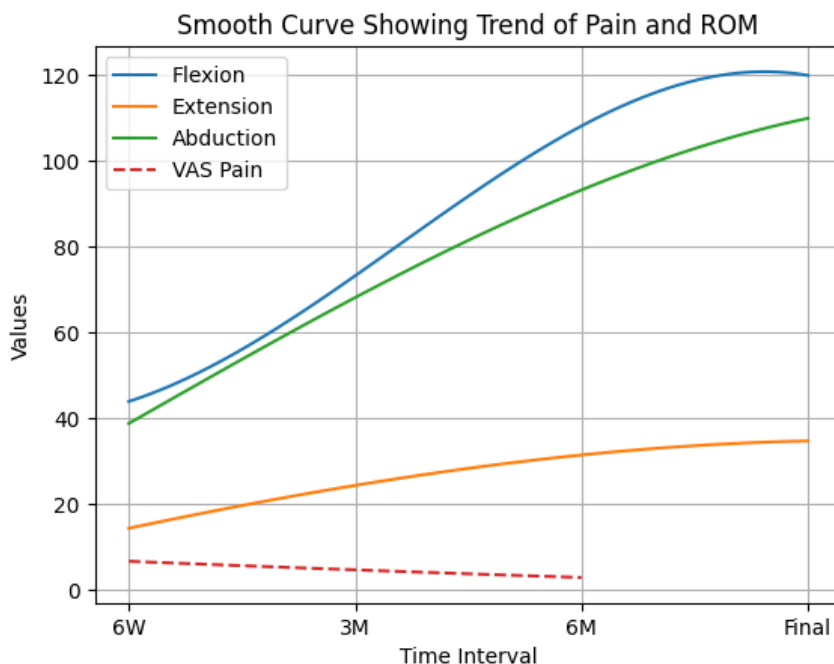
Regarding graft utilization, the 6 cm fibular strut graft was most commonly used (52.2%), followed by 7 cm (26.1%) and 8 cm (21.7%) grafts. The selection of graft length appeared to depend on the degree of metaphyseal comminution and the requirement for medial column support.

Clinical Outcomes – Pain and Range of Motion

Table 3: Pain (VAS) and Range of Motion at Different Time Intervals (N = 23)

Parameter	6 Weeks (Mean ± SD)	3 Months (Mean ± SD)	6 Months (Mean ± SD)	Final Follow-up (Mean ± SD)	p-value
VAS Pain Score	6.61 ± 1.20	4.61 ± 1.20	2.83 ± 0.94	—	<0.001*
Flexion (°)	43.87 ± 4.83	73.17 ± 5.84	108.09 ± 5.71	119.87 ± 3.99	<0.001*
Extension (°)	14.30 ± 2.69	24.30 ± 2.69	31.39 ± 2.59	34.65 ± 1.19	<0.001*
Abduction (°)	38.74 ± 4.75	68.09 ± 5.71	93.17 ± 5.78	109.87 ± 3.99	<0.001*

*Statistically significant at p < 0.05



Figure; 1 Pain (VAS) and Range of Motion at Different Time Intervals (N = 23)

Complications and Outcomes

Table 4: Complications, Time to Union, and Final Functional Outcome (N = 23)

Parameter	Category	Frequency (n)	Percentage (%)	Mean ± SD
Complications	None	21	91.3%	—
	Infection	1	4.3%	—
	Screw Perforation	1	4.3%	—
Time for Union (months)	—	—	—	7.83 ± 2.17
Final Outcome	Excellent	11	47.8%	—
	Good	9	39.1%	—

	Fair	2	8.7%	—
	Poor	1	4.3%	—
Total	—	23	100%	—

DISCUSSION

Management of Neer 3- and 4-part proximal humerus fractures in the elderly remains challenging due to osteoporotic bone, fracture comminution, and the risk of mechanical failure. The present study evaluated the outcomes of locking plate fixation augmented with fibular strut autograft and demonstrated satisfactory functional and radiological results with low complication rates.

The demographic profile of the present study showed a higher incidence in the 61–70 years age group with slight female predominance, consistent with osteoporotic fracture patterns reported in previous studies [1,2]. Most fractures in elderly patients are due to low-energy trauma, and compromised bone quality significantly affects fixation stability.

The mean operative time in this study (98.22 ± 7.78 minutes) was comparable to studies by Brunner et al. and Panchal et al., indicating that augmentation with fibular graft does not significantly prolong surgery when performed systematically [5,8]. The use of fibular strut grafts of varying lengths (6–8 cm) was tailored according to metaphyseal comminution, similar to recommendations by Gardner et al. [6].

A significant progressive improvement in pain and range of motion was observed over follow-up. The mean VAS score decreased substantially, while flexion, abduction, and extension improved significantly ($p < 0.001$). These findings are in agreement with studies by Matassi et al. and Panchal et al., which demonstrated that medial column support enhances stability and allows early mobilization, leading to better functional recovery [7,8].

Radiological union was achieved at a mean of 7.83 ± 2.17 months, which is comparable to existing literature [5,7]. The fibular strut graft acts as an internal support, maintaining the neck-shaft angle and preventing varus collapse, one of the most common causes of fixation failure in proximal humerus fractures [6].

The complication rate in the present study was low (8.7%), with only one case each of infection and screw perforation. Notably, there were no cases of avascular necrosis or implant failure during the follow-up period. This is lower compared to studies without medial support, where higher rates of screw cut-out and varus collapse have been reported [5,6]. The improved outcomes can be attributed to the biomechanical advantage provided by the fibular graft, which enhances construct stability, especially in osteoporotic bone.

Functional outcomes were favorable, with 86.9% of patients achieving excellent to good results. These findings are consistent with previous studies that emphasize the role of augmentation techniques in improving outcomes in complex proximal humerus fractures [7,8].

However, the study has certain limitations, including a small sample size, short follow-up duration, and lack of a control group. Long-term studies with larger populations are required to validate these findings and assess late complications such as avascular necrosis.

Overall, locking plate fixation augmented with fibular strut autograft appears to be a reliable technique for managing complex proximal humerus fractures in the elderly, providing good functional outcomes with minimal complications.

CONCLUSION

Locking plate fixation using a PHILOS plate augmented with fibular strut autograft is an effective and reliable method for the management of Neer 3- and 4-part proximal humerus fractures in elderly patients. The technique provides adequate medial column support, maintains fracture reduction, and prevents varus collapse, which are critical factors for successful outcomes in osteoporotic bone.

The present study demonstrated satisfactory fracture union, significant improvement in pain and range of motion, and a high proportion of excellent to good functional outcomes, with a low incidence of complications.

Thus, fibular strut graft augmentation with locking plate fixation can be considered a valuable surgical option for complex proximal humerus fractures in the elderly, offering improved stability and favorable clinical and radiological results.

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