

Functional Outcome in Post-operative Patients of Proximal Humerus Fractures Treated Using Proximal Humerus Nail

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ABSTRACT

Background: Proximal humerus fractures (PHFs) are a common fracture especially in the elderly age group. The incidence of proximal humerus fractures is expected to increase as elderly populations grow and osteoporosis prevalence increases. Nearly 85% of PHFs are minimally displaced and can be treated conservatively, but displaced fractures require anatomical reduction with internal fixation. Surgery aims to achieve early mobilisation and prompt return to pre-fracture activity level. Among all currently used methods of stabilising proximal humerus fractures, the best outcomes are achieved by angularly stable plate fixation and interlocking intramedullary nailing.

Methods: The study included patients with PHFs who underwent surgery at the Mandya Institute of Medical Sciences from April 2023 to September 2024. Functional outcome was assessed using the Constant Murley Score (CMS) for the shoulder. Patients were followed up regularly for 6 months post-operatively.

Results: In this 35-patient series, 57% were female, and the mean age was 53 years. Self-fall from standing height was the nature of trauma in 62.9% of the patients, and 62.85% of the patients presented with left-sided PHF. The majority (74.3%) of patients presented with a 2-part fracture according to Neer's classification. The functional outcomes indicated good recovery of shoulder function, with a final follow-up mean CMS of 74.94 points, comparable to those reported in the literature.

Conclusion: The study confirms that proximal humerus nails are an effective treatment option for 2- and 3-part PHFs, yielding reliable outcomes comparable to locking plate fixation.

Key-words: Proximal humeral nail (PHN); Proximal humerus fractures (PHFs); Constant-Murley Score (CMS); Neer's classification

INTRODUCTION

Proximal humerus fractures are among the most common fractures, especially in the elderly. They account for about 45% of all Humeral fractures and 5-7% of all whole-body fractures. The incidence of proximal humerus fractures can be expected to increase with an increase in injuries resulting from road traffic accidents and a growing number of elderly populations with osteoporosis.

The most common mechanism leading to a proximal humerus fracture is a fall from standing height onto an outstretched hand.^[1]

Nearly 85% of proximal humerus fractures are minimally displaced and can be treated by conservative means.^[2] Minimally displaced fractures, regardless of the number of fracture lines, can be treated with closed reduction, but displaced fractures require anatomical reduction with internal fixation. Antegrade nailing, with its advantages of minimal wound size and soft-tissue dissection, and superior biomechanical stability proven in two-part surgical neck fractures, can be considered a better alternative for the treatment of proximal humerus fractures.^[3]

The Association for Osteosynthesis (AO) approved the third-generation multi-locking antegrade intramedullary nail, launched in 2011 and designed to improve

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osteosynthesis stability by nailing. The straight nail design with central insertion point prevents injury to the supraspinatus muscle attachments on the head, reduces the risk of humeral head necrosis, and avoids potential insertion through the fracture site. The bi-cortical compression feature, ascending calcar screw option, and multi-planar distal locking significantly improve anti-rotation and bending functions and prevent humeral head varus deformity or greater tuberosity displacement due to their superior axial and shear stability.^[4-6]

Due to a lack of literature on the clinical outcomes of third-generation antegrade multi-locking nail implants in the Indian setting, our study aims to evaluate the functional outcomes of proximal humerus fractures treated with the multi-locking humeral nail, an intramedullary fixation device.

MATERIALS AND METHODS

Research design- Descriptive longitudinal observation study with a follow-up for 6 months. Post-operative patients at the Department of Orthopedics, Mandya Institute of Medical Sciences, Mandya, following internal fixation of proximal humerus fractures using the proximal humerus nail were included in the study from April 2023 to September 2024 after written informed consent from the patient.

Methodology- From the hospital records, patient details, pre-operative evaluation, and the surgical procedure undergone were obtained. All fractures were operated on electively by a senior trauma surgeon under general anesthesia and/or Brachial plexus blocks. All patients were administered IV Ceftriaxone 1g 30 minutes before skin incision.

The implant used at the institute was a solid nail of 316L stainless steel measuring 160mm in length, with 4 multiaxial interlocking bolts proximally and 2 interlocking bolts distally inserted from lateral to medial. The interlocking bolts were available in diameters of 3 mm for distal interlocking and 3.7 mm and 5 mm for proximal interlocking, with lengths ranging from 12 mm to 40 mm. The nail was available in diameters of 6 mm, 7 mm, 8 mm and 9 mm.

- ✓ Intravenous second/third-generation cephalosporins were administered for 2 days postoperatively.
- ✓ In the immediate postoperative period, patients were placed in a sling or shoulder immobilizer.

Pendulum exercises and active range-of-motion exercises at the elbow, wrist, and hand were encouraged from the first postoperative day.

- ✓ Patients were discharged on 2nd postoperative day
- ✓ Patients were assessed sequentially during their routine post-operative visits to the outpatient clinic at 2nd post-operative week, 6 weeks, 12 weeks, and 6 months after surgery.
- ✓ Any complaints and history were obtained, clinical examination findings were noted on the proforma, and the patient underwent postoperative orthogonal radiographs of the shoulder and proximal humerus at each visit.

Constant-Murley score (CMS) is a 100-point scale composed of the following parameters:

1. Pain (15 points)
2. Activities of daily living (20 points)
3. Strength (25 points)
4. Range of motion:(40 points).

The Constant and Murley scoring system was interpreted as adopted by the European Society for Shoulder and Elbow Surgery as

1. Excellent: Score between 86 and 100
2. Good: Score between 71 and 85
3. Moderate: Score between 56 and 70
4. Poor: Score less than 55

Inclusion Criteria

- 1) Patients who are aged 18 years and above, of both sexes.
- 2) Closed proximal humerus fractures treated by proximal humeral nail fixation
- 3) Patients who will give written informed consent to participate in the study.

Exclusion Criteria

- 1) Pathological fractures.
- 2) Fractures with compartment syndrome or impaired circulation.
- 3) History of prior shoulder injuries on the affected side.
- 4) If associated with other fractures of the same limb.
- 5) Co-morbidity affecting muscle strength and neurological deficits affecting the same limb

Statistical Analysis- Descriptive statistical methods, including measures of central tendency, standard deviation, coefficient of skewness, and kurtosis, were applied to summarize the data. Inferential statistical techniques, the independent Student's t-test was employed to compare means and assess the significance of findings within the study.

Ethical Approval- Institutional Scientific Committee and Institutional Ethics Committee approval was obtained from Mandya Institute of Medical Sciences before the commencement of the study. The study was conducted following standard ethical guidelines, and confidentiality of participants was maintained throughout.

RESULTS

The mean age was 53 years, with the youngest being 24 and the oldest being 85. There was a bimodal distribution, with elderly patients accounting for 37.14% and young adults (18 to 40 years) accounting for 34.28%. The study included 15 male (42.86%) and 20 female (57.14%) patients. In 22 patients, the left side was involved, and in 13 patients, the right side was involved. 11 cases were due to Road traffic accidents, and 22 cases were due to self-fall. 2 cases gave a history of direct trauma. Most patients (26) had Neer's 2-part fractures involving the surgical neck, while 5 had 3-part fractures with the head, shaft, and greater tuberosity as the main fragments, and 4 had 4-part fractures (Table 1).

Table 1: Distribution of patients according to age, gender, side of involvement, mode of injury and fracture classification (Neer's classification)

Age (years)	No of patients	Percentage (%)
18-40	12	34.28
41-60	10	28.57
61-80	12	34.28
>81	1	2.85
Gender		
Male	15	42.86
Female	20	57.14
Side		
Left	22	62.9
Right	13	37.1
Mode of Injury		
RTA	11	31.4
Self-fall	22	62.9
Direct trauma	2	5.7
Neer's Classification		
2-part	26	74.29
3-parts	5	14.28
4-parts	4	11.42

The average blood loss during the surgery was around 125ml, and the average surgical duration was 75 minutes. At the final follow-up, the average Constant-Murley score of the study sample was 74.94, with a standard deviation of 8.01. The maximum score was 89, while the minimum was 56, with a median of 73. Six

patients showed excellent outcomes with scores over 85, 21 patients showed good outcomes with scores exceeding 70 but less than 86, and 8 patients had a fair outcome, i.e., a score between 56 and 70. No patient had a poor CMS outcome at the end of 6 months (Tables 2 and 3).

Table 2: Functional outcome according to CMS (average scores) and incidence of complications and fracture union radiologically

		6 weeks	12 weeks	6 months
Pain (15 points)		10.05	11.8	12.4
Activities of daily living (20 points)		12.71	14.77	15.88
Range of Movements (40 points)		21.71	26.74	32
Strength (25 points)		4.71	9.97	14.2
Total Constant Murley score (100 points)		49.43	63.86	74.94
Complications	Stiffness	5	7	7
	Impingement	3	4	4
	Infection	1	-	-
	Implant failure	-	-	-
	Malunion	-	3	3
Radiological union		20	31	35

Table 3: Functional outcome frequency distribution based on CMS at follow-up visits

Category	6 Weeks	3 Months	6 Months	Fracture classification
Excellent (86-100)	0	0	6(17.1%)	2- part: 5
				3-part:0
				4-part:0
Good (71-85)	0	13(37.1%)	21(60%)	2- part: 15
				3-part:3
				4-part:2
Fair (56-70)	11(31.4%)	18(51.4%)	8(22.8%)	2- part: 6
				3-part:2
				4-part:2
Poor (<56)	24 (68%)	4(%)	0	0

Table 4 summarizes Constant–Murley Scale (CMS) outcomes and related clinical parameters. Pain scores showed moderate negative correlations with age and Neer’s classification, indicating better pain outcomes in younger patients and less complex fractures, while comorbidities were associated with higher pain levels. Higher pain scores correlated with improved shoulder range of motion at 6 months. Mean range of motion and strength scores reflected satisfactory functional

recovery. CMS scores improved progressively across all fracture types, with 2-part fractures showing slightly higher values; the outcome differed significantly across Neer’s classifications ($p=0.02$). No significant differences in CMS were observed based on mechanism of injury, side of injury, or gender. Complications were minimal and managed conservatively, with isolated cases of malunion and superficial infection (2.85% each).

Table 4: Comparison of results with similar studies

	Present study (Proximal humerus nail)	Chen <i>et al.</i> (3rd gen: MultiLoc[®] nail) [12]	Guo <i>et al.</i> (2nd generation Interlocking nail) [13]	Lin Wu <i>et al.</i> (MultiLoc[®] nail)	Kumar <i>et al.</i> (Locking plate) [14]
Number of patients	35	48	28	58	52
Mean Age in years (range)+/- SD	53 (24-85)	58.6 (40-75)	65.6+/-11.2	42.15 +/- 13.26	57.85+/- 13.81
Males	15 (42%)	20 (41.6%)	10 (35.71%)	35 (60.54%)	26 (63.4%)
Females	20 (57%)	28 (58.3%)	18 (64.29%)	23 (39.66%)	15 (36.6%)
Mode of injury					
High-energy mechanism	11 (31.4%)	Not reported	9 (32.14%)	36 (62.06%)	Not reported
Low-energy injury mechanism	22 (62.9%)	Not reported	19 (67.86%)	20 (34.48%)	Not reported
Fracture classification					
2-part	26 (74.2%)	13 (27%)	11 (39.28%)	37 (63.79%)	11 (21.15%)
3-part	5 (14.2%)	25 (52.1%)	15 (53.57%)	21 (36.21%)	22 (42.30%)
4-part	4 (11.4%)	10 (26.8%)	2 (7.14%)	-	19 (36.53)
Surgical duration (Average, in min)	75 (range 60- 90)	96.4 +/-26.4	102.6+/- 22.1	81.46+/-10.37	Not reported
Intraoperative blood loss (Average, in mL)	125 (range 100-150)	59 +/-24.7	72.5+/-10.5	186.46+/- 16.39	Not reported
Constant-Murley score					
4-6 weeks	49.43+/-7.67	Not reported	45.1+/-9.6	~36	Not reported
6 months	74.94+/-8.01	Not reported	70.6+/-7.9	~77.5	Not reported
Final follow-up	74.94+/-8.01	68+/6.4	83.1+/-5.3	~77.5	72.34+/- 13.57

Total complications	7 (20%)	12 (25%)	3 (10.7%)	0 (0%)	18 (43%)
Stiffness/Adhesive capsulitis	3 (8.57%)	8 (16.7%)	-	-	-
Subacromial Impingement	2 (5.71%)	4 (8.3%)	2 (7.14%)	-	5 (12%)
Malunion	1 (2.85%)	-	1 (3.57%)	-	7 (17%)
Infection	1 (2.85%)	-	-	-	1 (2%)
Screw cut out/backout	-	-	-	-	4 (10%)
Non-union	-	-	-	-	1 (2%)

DISCUSSION

Proximal humerus fractures predominantly affect the elderly population, particularly females, largely due to osteoporosis and age-related reduction in bone quality. Previous studies have highlighted that compromised bone stock significantly influences fracture pattern, fixation stability, and healing potential, irrespective of the trauma mechanism. Osteoporotic bone has also been associated with higher risks of complications such as malunion, non-union, and humeral head necrosis, especially following open reduction and plating techniques [7,8].

Younger patients, on the other hand, typically sustain proximal humerus fractures following high-energy trauma such as road traffic accidents or direct impact injuries. However, even in these cases, fracture severity and postoperative functional outcomes depend more on fracture morphology and fixation stability rather than the energy of trauma alone. Contemporary biomechanical and clinical studies have demonstrated that minimally invasive fixation techniques can provide reliable stability while preserving fracture biology [9–11].

In the present study, the mean age was 53 years (range 24–85), with a bimodal distribution, and females constituted 57% of the study population. Similar demographic patterns have been reported by Chen et al., who observed a mean age of 58.6 years in patients treated with MultiLoc® nails, and by large epidemiological studies that highlight a female predominance in elderly age groups. This gender difference has been attributed to osteoporosis and increased fall risk in post-menopausal women [12,15–17].

Low-energy trauma due to self-fall accounted for 62.9% of fractures in the present study, predominantly among elderly patients, whereas high-energy mechanisms were more common in younger individuals. These findings are consistent with previous studies reporting that most proximal humerus fractures in patients aged 45 or older occur following simple falls. Notably, several authors have emphasized that fixation outcomes are more closely related to bone quality and adequacy of reduction than to the injury mechanism itself [16,17].

Regarding fracture patterns, 74.2% of patients in the present series had Neer's 2-part fractures, followed by 3-part (14.2%) and 4-part fractures (11.4%). This distribution is comparable to reports by Chen et al. and other large cohort studies. Four-part fractures remain technically demanding, particularly for closed reduction and intramedullary fixation, and may require open reduction, locking plate fixation, or arthroplasty in elderly patients with poor bone stock [12,17,18].

The mean surgical duration in this study was 75 minutes with an average blood loss of 125 mL, which is lower than values reported for locking plate fixation in multiple studies. Reduced operative time and blood loss with intramedullary nailing have been attributed to minimal soft-tissue dissection and preservation of periosteal blood supply, factors known to improve fracture healing and reduce postoperative morbidity [9,10,16,20].

Functional outcomes assessed using the Constant–Murley Score demonstrated progressive improvement over time, with a mean score of 74.94±8.01 at final follow-up. Similar improvements have been reported in previous studies evaluating intramedullary nailing systems, including second- and third-generation designs,

confirming their effectiveness in restoring shoulder function in 2- and selected 3-part fractures [11–13,16].

Pain relief, range of motion, strength, and activities of daily living were better in patients with less complex fractures and younger age groups. No statistically significant differences were observed based on gender, side of injury, or mechanism of trauma. These findings support existing evidence that fracture complexity and bone quality are the primary determinants of outcome following proximal humerus fracture fixation [12,16,17,20–22]. The overall complication rate in the present study was 20%, with stiffness being the most common complication. All complications were managed conservatively without the need for revision surgery. Comparable complication rates have been reported in other studies evaluating intramedullary nailing, with lower incidences of implant-related failures when newer straight nail designs and careful surgical techniques are employed [12,16,25].

Compared with locking plate fixation, proximal humerus nailing demonstrated comparable or superior functional outcomes with fewer soft-tissue complications. The load-sharing nature of intramedullary fixation and reduced disruption of fracture biology make it a reliable treatment option for 2- and selected 3-part proximal humerus fractures, particularly in osteoporotic bone [20,27–29].

CONCLUSIONS

The results of this study provide valuable insights into the management of proximal humerus fractures. The locking PHN allows for early mobilisation, a greater range of motion, shorter surgical duration, lower blood loss, and reliable outcomes comparable to those of locking plate fixation. Most patients achieved substantial functional recovery, with a mean Constant-Murley score of 74.94 at 6 months. Better outcomes were observed in 2-part fractures. Complication rates, primarily stiffness and impingement, were within expected limits and similar to those in other large studies and can be avoided wherever possible by meticulous surgical technique to maintain sufficient reduction, accommodate the proximal limb of the nail within the head for better proximal multi-axial screw purchase and early mobilisation should be done in stable fixation to avoid unsatisfactory outcomes.

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