Section: Orthopaedics

Case Series

# FUNCTIONAL OUTCOME FOLLOWING INTERNAL FIXATION OF PROXIMAL HUMERUS SURGICAL NECK TWO- AND THREE-PART FRACTURES WITH POLARIS NAIL

***Ramesh M[1], Manesh Chacko Philip[2], Ranju Raj[3]***

*[1]Professor, Department of Orthopaedics, Jubilee Mission Medical College and Research Institute, Thrissur, Kerala, India*
*[2]Associate Professor, Department of Orthopaedics, Jubilee Mission Medical College and Research Institute, Thrissur, Kerala, India*
*[3]Assistant Professor, Department of Orthopaedics, Jubilee Mission Medical College and Research Institute, Thrissur, Kerala, India*

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**Corresponding Author:**
**Dr. Ramesh M,**
Professor, Department of Orthopaedics, Jubilee Mission Medical College and Research Institute, Thrissur, Kerala, India.
Email: mrameshnairm@gmail.com

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ABSTRACT

**Background:** Proximal humerus fractures are common injuries accounting for approximately 4–6% of all adult fractures. Displaced fractures involving the surgical neck may result in significant functional impairment if not managed appropriately. Intramedullary fixation has emerged as a minimally invasive alternative to plate fixation, offering stable fixation while preserving soft tissue and vascular supply. The Polaris intramedullary nail has been specifically designed for proximal humerus fractures and provides multiple proximal locking options to improve stability. The objective is to evaluate the clinical and radiological outcomes of Polaris intramedullary nailing in the management of displaced two-part and three-part surgical neck fractures of the proximal humerus.

**Materials and Methods:** This prospective case series included 25 patients with displaced proximal humerus fractures treated with Polaris intramedullary nailing at a tertiary care orthopaedic centre over a period of two years. Patients with Neer two-part and three-part surgical neck fractures were included. Functional outcomes were assessed using the Constant–Murley shoulder score, and radiological union was evaluated using serial radiographs during follow-up. Statistical analysis was performed using IBM SPSS software version 26.0.

**Results:** The mean patient age was 54.6 ± 12.8 years. The majority of patients were male (64%). Two-part fractures accounted for 60% of cases, while three-part fractures constituted 40%. Radiological union was achieved in 24 patients (96%), with most fractures healing within 10–12 weeks. The mean Constant–Murley score at final follow-up was 78.6 ± 9.4. Good to excellent functional outcomes were observed in 80% of patients. The mean forward flexion was 142.5° and mean abduction was 135.4°. Postoperative complications occurred in three patients (12%), including shoulder stiffness, screw irritation, and delayed union. No cases of deep infection, implant failure, or avascular necrosis were observed.

**Conclusion:** Polaris intramedullary nailing provides reliable fixation for displaced two-part and three-part surgical neck fractures of the proximal humerus. The technique allows early mobilization and results in high union rates with satisfactory functional outcomes and a low complication rate. Intramedullary fixation may therefore be considered an effective surgical option for selected proximal humerus fractures.

**Keywords:** Proximal humerus fracture; Intramedullary nailing; Polaris nail; Surgical neck fracture; Constant–Murley score; Shoulder fracture fixation.

## INTRODUCTION

Proximal humerus fractures represent one of the most common fractures of the upper extremity, accounting for approximately 4–6% of all adult fractures and forming a substantial proportion of injuries encountered in orthopaedic practice.[1] The incidence of these fractures has increased steadily over the past decades, largely due to the growing elderly population and the higher prevalence of osteoporosis. Most injuries occur following low-energy falls in older individuals, while high-energy trauma such as road traffic accidents tends to be responsible for fractures in younger patients.[2] Among the different fracture patterns described in the Neer classification system, two-part and three-part fractures involving the surgical neck of the humerus are frequently encountered and often require surgical intervention when displacement compromises alignment and shoulder function.

Management of displaced proximal humerus fractures remains a subject of ongoing debate. Although many minimally displaced fractures can be managed successfully with conservative treatment, displaced fractures often lead to functional impairment if not stabilized adequately.[3] Various operative techniques have been described for the treatment of these fractures, including locking plate fixation, percutaneous pinning, intramedullary nailing, and arthroplasty in complex cases. Each method carries its own advantages and potential complications. Locking plate systems have gained popularity due to their ability to provide angular stability, but they may be associated with complications such as screw penetration, loss of reduction, and disruption of the humeral head blood supply, particularly in osteoporotic bone.[4]

Intramedullary fixation has emerged as an alternative method that aims to provide stable fracture fixation while minimizing soft-tissue disruption. By positioning the implant within the medullary canal, intramedullary devices act as load-sharing constructs and require less periosteal stripping compared with plate fixation. The Polaris intramedullary nail was designed specifically for proximal humerus fractures and incorporates multiple proximal locking options to improve fixation within the humeral head and enhance rotational stability.[5] These biomechanical characteristics allow for stable fixation while potentially facilitating earlier mobilization of the shoulder joint.

Despite these theoretical advantages, the clinical outcomes of intramedullary nailing in proximal humerus fractures continue to be evaluated, particularly with regard to functional recovery, fracture union, and complication rates. Evidence from clinical studies suggests that intramedullary nails can provide satisfactory outcomes in selected fracture patterns, especially in two- and three-part fractures involving the surgical neck of the humerus. However, variations in surgical technique, patient characteristics, and implant design may influence the final outcome. Consequently, further clinical evaluation is warranted to better understand the effectiveness of this technique in routine orthopaedic practice.

The present study aims to evaluate the clinical and radiological outcomes of Polaris intramedullary nailing in the management of displaced two- and three-part surgical neck fractures of the proximal humerus. By analysing a case series of patients treated at a single centre, this study seeks to assess fracture union, functional recovery based on the Constant–Murley score, and the incidence of procedure-related complications.

## MATERIALS AND METHODS

**Study Design and Setting:** This study was conducted as a prospective case series at a tertiary care orthopaedic centre over 2 years, from January 2023 to December 2024. The aim of the study was to evaluate the clinical and radiological outcomes of displaced proximal humerus fractures treated with Polaris intramedullary nailing. Ethical approval was obtained from the Institutional Ethics Committee before initiation of the study. All procedures were carried out in accordance with accepted ethical standards for clinical research involving human participants.[6] Written informed consent was obtained from all patients prior to participation in the study.

**Study Population:** A total of 25 consecutive patients presenting with displaced proximal humerus fractures involving the surgical neck were included in the study. Patients were recruited from the orthopaedic trauma services of the institution after initial evaluation in the emergency department or outpatient department. Baseline demographic details including age, sex, mechanism of injury, and side of involvement were recorded at the time of admission.

**Inclusion Criteria**

Patients fulfilling the following criteria were included in the study:

- Age 18 years and above
- Neer two-part surgical neck fractures of the proximal humerus
- Neer three-part proximal humerus fractures
- Closed fractures
- Patients medically fit for surgery
- Patients willing to participate in the study and comply with follow-up

**Exclusion Criteria**

Patients meeting any of the following criteria were excluded:

- Four-part proximal humerus fractures
- Head-splitting fractures
- Pathological fractures
- Open fractures
- Associated neurovascular injury around the shoulder

- Previous surgery involving the proximal humerus
- Pre-existing shoulder pathology affecting function
- Patients medically unfit for anesthesia or surgery

**Preoperative Evaluation:** All patients underwent a detailed clinical examination at the time of presentation. Radiographic evaluation included anteroposterior and axillary or scapular Y views of the affected shoulder to determine fracture configuration and displacement. Fractures were classified according to the Neer classification system. Routine preoperative investigations and anaesthetic evaluation were performed to assess surgical fitness.

**Surgical Technique:** All procedures were performed under general anesthesia with the patient positioned in the beach-chair position on a radiolucent operating table. Closed reduction of the fracture was attempted under fluoroscopic guidance. A small incision was made over the anterolateral aspect of the shoulder, and a deltoid-splitting approach was used to expose the entry point.

The entry point for nail insertion was created just medial to the greater tuberosity at the apex of the humeral head under fluoroscopic guidance. A guidewire was introduced into the medullary canal and advanced distally across the fracture site. After confirming satisfactory guidewire position, the canal was prepared as necessary and the Polaris intramedullary nail was inserted over the guidewire.

Multiple proximal locking screws were inserted into the humeral head to provide stable fixation and rotational stability. Distal locking screws were then placed to secure the nail within the humeral shaft. Adequate fracture reduction and implant positioning were confirmed using intraoperative fluoroscopy before wound closure.

**Postoperative Protocol:** Following surgery, the affected limb was supported in an arm sling for comfort. Early passive range-of-motion exercises were initiated once pain permitted, usually within the first postoperative week. Gradual progression to active-assisted and active shoulder mobilization exercises was encouraged during subsequent follow-up visits. Patients were advised to avoid heavy lifting and strenuous activities until radiological evidence of fracture union was observed.

**Follow-Up and Outcome Assessment:** Patients were followed up at regular intervals at six weeks, three months, and six months after surgery. At each visit, clinical evaluation and radiographic assessment were performed to assess fracture healing and shoulder function. Radiological union was defined as the presence of bridging callus across the fracture site on radiographs along with absence of pain during shoulder movement.

Functional outcome was assessed using the Constant–Murley shoulder score, which evaluates pain, activities of daily living, range of motion, and shoulder strength. Shoulder range of motion was measured using a standard goniometer. Any intraoperative or postoperative complications, including infection, implant-related complications, or shoulder stiffness, were documented during the follow-up period.

**Statistical Analysis:** Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as age, time to fracture union, and Constant–Murley scores were expressed as mean ± standard deviation (SD). Categorical variables including sex distribution, fracture type, mechanism of injury, and complications were presented as frequencies and percentages.

## RESULTS

**Patient Demographics and Injury Characteristics:** A total of 25 patients with displaced proximal humerus fractures involving the surgical neck were included in the study and completed the required follow-up period. The mean age of the patients was 54.6 ± 12.8 years (range, 32–76 years). The majority of patients were male (16 patients, 64.0%), while 9 patients (36.0%) were female.

With respect to the side of injury, the right shoulder was involved in 15 patients (60.0%), whereas 10 patients (40.0%) sustained fractures on the left side.

The most common mechanism of injury was road traffic accidents, accounting for 14 cases (56.0%), followed by falls from standing height in 8 patients (32.0%), and falls from height in 3 patients (12.0%). These findings indicate that proximal humerus fractures in the present cohort were more frequently associated with high-energy trauma and occurred predominantly in male patients.

Detailed demographic characteristics are summarized in [Table 1].

**Table 1: Demographic characteristics of the study population**

| Variable | Number of Patients (n=25) | Percentage |
|---|---|---|
| Male | 16 | 64% |
| Female | 9 | 36% |
| Right side involvement | 15 | 60% |
| Left side involvement | 10 | 40% |

**Fracture Pattern Distribution:** Fractures were classified according to the Neer classification system based on preoperative radiographic evaluation.

In the present study, two-part surgical neck fractures were the most common fracture pattern, accounting for 15 cases (60.0%), while three-part fractures were observed in 10 patients (40.0%).

The predominance of two-part fractures reflects the typical fracture pattern encountered in displaced surgical neck injuries requiring operative fixation.

The distribution of fracture patterns is presented in [Table 2].

**Table 2: Distribution of fracture types**

| Fracture Type | Number of Patients | Percentage |
|---|---|---|
| Neer two-part fracture | 15 | 60% |
| Neer three-part fracture | 10 | 40% |

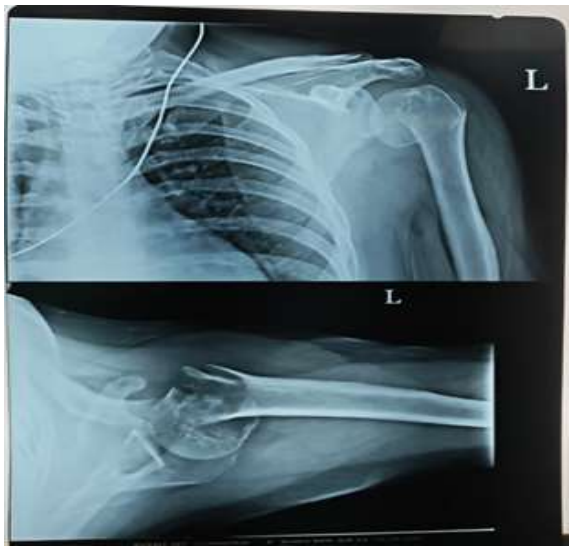


**Figure 1: Preoperative Radiograph**

Pre-operative X-ray showing proximal humerus fracture (Left).

**Operative Characteristics:** All patients underwent fixation using the Polaris intramedullary nail under fluoroscopic guidance. Closed reduction was achieved in the majority of cases, while minimal open assistance was required in a small number of patients to achieve satisfactory fracture alignment.

The mean operative duration was 68.4 ± 11.2 minutes, indicating that the procedure could be performed within a reasonable operative time. The average duration of hospital stay was 4.3 ± 1.2 days, reflecting early postoperative recovery and mobilization following intramedullary fixation.

Overall, the surgical procedure was completed successfully in all patients without any intraoperative complications.

Operative parameters are summarized in [Table 3].

**Table 3: Operative details**

| Parameter | Mean ± SD | Parameter |
|---|---|---|
| Operative time (minutes) | 68.4 ± 11.2 | Operative time (minutes) |
| Hospital stays (days) | 4.3 ± 1.2 | Hospital stays (days) |

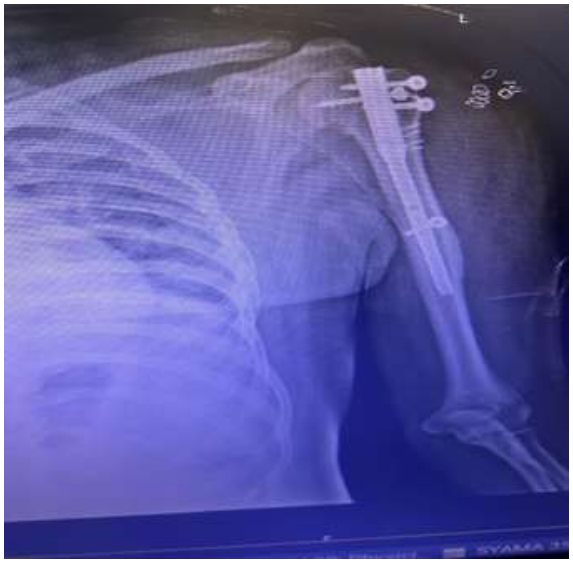

**Figure 2: Immediate Postoperative Radiograph**

Immediate post-operative X-ray showing fixation with Polaris intramedullary nail.

**Radiological Union Over Follow-Up:** Radiological evaluation of fracture healing was performed during regular follow-up visits. Progressive evidence of callus formation and cortical bridging was observed during sequential radiographic assessments.

At 6 weeks, early radiological signs of healing were observed in 7 patients (28.0%). By 10–12 weeks, radiological union was achieved in 14 patients (56.0%), representing the majority of the study population. At more than 12 weeks, an additional 3 patients (12.0%) demonstrated complete fracture union.

Overall, 24 patients (96.0%) achieved successful radiological union during the follow-up period. One patient (4.0%) developed delayed union but subsequently progressed to union with continued conservative management and physiotherapy.

These findings demonstrate a high rate of fracture healing following intramedullary fixation with the Polaris nail.

The detailed distribution of fracture union over time is presented in [Table 4].

**Table 4: Time to fracture union**

| Time to Union | Number of Patients | Percentage |
|---|---|---|
| <10 weeks | 6 | 24% |
| 10–12 weeks | 14 | 56% |
| >12 weeks | 5 | 20% |

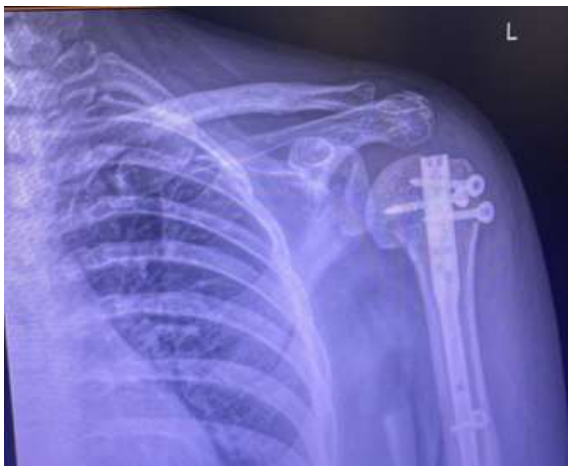

**Figure 3: Follow-up Radiograph**

Follow-up X-ray demonstrating maintained reduction and implant position.

**Functional Outcome at Final Follow-Up:** Functional outcomes were assessed using the Constant–Murley shoulder score at the final follow-up visit.

The mean Constant–Murley score was 78.6 ± 9.4, indicating satisfactory functional recovery in the majority of patients.

Based on Constant score grading, excellent functional outcomes were observed in 11 patients (44.0%), while good outcomes were achieved in 9 patients (36.0%). Four patients (16.0%) demonstrated fair results, and one patient (4.0%) had a poor functional outcome.

Overall, 20 patients (80.0%) achieved good to excellent functional outcomes, suggesting that intramedullary fixation provided effective restoration of shoulder function.

The distribution of functional outcomes is summarized in [Table 5].

**Table 5: Functional outcome according to Constant–Murley score**

| Outcome Category | Number of Patients | Percentage |
|---|---|---|
| Excellent | 11 | 44% |
| Good | 9 | 36% |
| Fair | 4 | 16% |
| Poor | 1 | 4% |

**Range of Motion Outcomes:** At final follow-up evaluation, most patients demonstrated satisfactory restoration of shoulder mobility.

The mean forward flexion was 142.5° ± 18.6°, while the mean shoulder abduction was 135.4° ± 20.1°. The mean external rotation was 48.7° ± 9.5°, and the mean internal rotation reached the level of the T12 vertebra in most patients.

These findings indicate that stable fixation with the Polaris intramedullary nail allowed early mobilization and satisfactory recovery of shoulder range of motion.

**Complications Observed During Follow-Up:** Postoperative complications were recorded throughout the follow-up period. Overall, complications occurred in three patients (12.0%).

One patient (4.0%) developed postoperative shoulder stiffness, which improved with physiotherapy. One patient (4.0%) experienced proximal screw irritation, which required implant removal after fracture union had been achieved. One patient (4.0%) developed delayed union, which eventually progressed to union without additional surgical intervention.

Importantly, no cases of deep infection, implant failure, or avascular necrosis of the humeral head were observed during the follow-up period.

The distribution of complications is summarized in [Table 6].

**Table 6: Complications observed in the study**

| Complication | Number of Patients | Percentage |
|---|---|---|
| Shoulder stiffness | 1 | 4% |
| Screw irritation | 1 | 4% |
| Delayed union | 1 | 4% |
| Total complications | 3 | 12% |

## DISCUSSION

The management of displaced proximal humerus fractures remains a subject of considerable discussion in orthopaedic practice. Surgical neck fractures, particularly Neer two-part and three-part injuries, may lead to persistent pain and functional limitation if anatomical alignment and stable fixation are not achieved. The present study evaluated the clinical and radiological outcomes of Polaris intramedullary nailing in the treatment of such fractures and demonstrated encouraging results with regard to fracture healing, shoulder function, and complication rates.

In the present series, the mean age of patients was 54.6 years, and the majority of injuries occurred in male patients following road traffic accidents. This pattern suggests that a substantial proportion of fractures in this cohort resulted from high-energy trauma. Previous clinical observations have similarly noted that proximal humerus fractures in relatively younger populations are frequently associated with high-energy mechanisms such as road traffic accidents, whereas low-energy falls are more commonly observed among elderly individuals with osteoporotic bone.[11] In addition, the predominance of two-part surgical neck fractures in our study is

consistent with previously reported epidemiological patterns of proximal humerus injuries.

Intramedullary fixation has gained increasing attention as an alternative surgical technique for the treatment of selected proximal humerus fractures. The Polaris intramedullary nail is designed to provide stable fixation through a minimally invasive approach while preserving the surrounding soft tissue envelope. In the present study, radiological union was achieved in 96% of patients, with a mean time to fracture healing of approximately 11 weeks. The high rate of fracture union observed in this series supports the concept that intramedullary fixation can provide sufficient mechanical stability while maintaining the biological environment necessary for fracture healing.

Functional recovery following proximal humerus fracture fixation is an important determinant of overall patient outcome. In the present study, the mean Constant–Murley score was 78.6, and 80% of patients achieved good to excellent functional outcomes at the final follow-up. These findings suggest that intramedullary fixation with the Polaris nail allows satisfactory restoration of shoulder function in the majority of cases. Similar functional outcomes have been reported in previous studies evaluating intramedullary nailing techniques, where stable fixation enabled early mobilization and satisfactory recovery of shoulder function in patients with displaced proximal humerus fractures.[12]

Range of motion assessment in our study demonstrated satisfactory recovery of shoulder mobility at the final follow-up visit. Most patients achieved acceptable degrees of forward flexion, abduction, and external rotation, reflecting the benefits of early rehabilitation following stable fracture fixation. Previous investigations have emphasized that early postoperative mobilization is a critical factor influencing functional recovery after proximal humerus fracture surgery, and intramedullary fixation may facilitate this process by minimizing soft tissue disruption and preserving the vascularity of the humeral head.[13]

The overall complication rate observed in this study was relatively low. Postoperative complications occurred in three patients (12%), including shoulder stiffness, screw irritation, and delayed union. Importantly, no cases of deep infection, implant failure, or avascular necrosis of the humeral head were observed during the follow-up period. These findings are consistent with previous reports suggesting that intramedullary fixation may be associated with a favorable complication profile when used in appropriately selected fracture patterns and when careful surgical technique is employed.[14]

Despite these encouraging results, several limitations should be considered when interpreting the findings of this study. First, the investigation was conducted as a single-center case series without a comparison group, which limits the ability to directly compare outcomes with other treatment modalities such as locking plate fixation or conservative management. Second, the sample size was relatively small, which may limit the generalizability of the results. In addition, the duration of follow-up may not have been sufficient to detect certain late complications, including avascular necrosis of the humeral head.

Nevertheless, the findings of the present study contribute to the growing body of evidence supporting the use of intramedullary fixation in selected proximal humerus fractures. The results indicate that Polaris intramedullary nailing can provide stable fixation, facilitate early mobilization, and achieve satisfactory clinical outcomes in patients with displaced two-part and three-part surgical neck fractures of the proximal humerus.[15] Further prospective studies with larger patient cohorts and longer follow-up periods are warranted to better define the role of intramedullary nailing in the management of proximal humerus fractures and to compare its outcomes with other established surgical techniques.

## CONCLUSION

The findings of the present study indicate that Polaris intramedullary nailing is an effective surgical option for the management of displaced two-part and three-part surgical neck fractures of the proximal humerus. The technique provided stable fracture fixation, which allowed early mobilization of the shoulder joint and facilitated satisfactory functional recovery in the majority of patients.

A high rate of radiological fracture union was observed in this series, with most fractures healing within the expected time frame. Functional assessment using the Constant–Murley score demonstrated predominantly good to excellent outcomes, suggesting that intramedullary fixation can restore shoulder function effectively when appropriate patient selection and surgical technique are employed.

The overall complication rate was low, and no major implant-related failures or avascular necrosis of the humeral head were observed during the follow-up period. These findings suggest that Polaris intramedullary nailing offers a reliable and minimally invasive method of fixation for selected proximal humerus fractures while preserving the biological environment necessary for fracture healing.

However, the results of this study should be interpreted in the context of certain limitations, including the relatively small sample size and the absence of a comparison group. Further prospective studies with larger patient populations and longer follow-up durations are required to confirm these findings and to compare intramedullary nailing with other commonly used treatment modalities for proximal humerus fractures.

In conclusion, Polaris intramedullary nailing provides satisfactory clinical and radiological outcomes in patients with displaced surgical neck fractures of the proximal humerus and may be

considered a valuable treatment option in appropriately selected cases.

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