

# Intramedullary Nailing in Proximal Humerus Fractures: Outcomes Beyond the Simple Two-Part

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## Abstract

**Background:** Proximal humerus fractures (PHFs) are common injuries, particularly in the elderly. While intramedullary nailing (IMN) has gained popularity for treating these fractures, its efficacy in complex cases, especially those with comminuted calcar, remains a topic of debate. This study aimed to evaluate the outcomes of IMN in PHFs with and without calcar comminution.

**Methods:** A prospective observational study was conducted on 40 patients with displaced PHFs treated with IMN. Patients were divided into two groups based on the integrity of the calcar: intact (group A) and comminuted (group B). Radiographic and clinical outcomes were assessed at 3, 6, and 12 months postoperatively.

**Results:** All fractures achieved union. Minimal loss of reduction was observed in both groups, with no significant difference between them. Functional outcomes, including pain, range of motion (ROM), and patient-reported scores, improved over time in both groups. Patients with intact calcar showed significantly better outcomes in terms of Simple Shoulder Test (SST) score and forward elevation at all follow-up points. The complication rate was low (2.5%), with one case of osteonecrosis in group A.

**Conclusion:** IMN is a safe and effective treatment for displaced PHFs, even with comminuted calcar. Although calcar comminution may lead to slightly worse outcomes in specific functional parameters, the overall impact is minimal. IMN offers a viable alternative to plate fixation, particularly in complex fractures, with favorable outcomes and a low complication rate.

**Keywords:** Proximal Humeral Fractures; Intramedullary Fracture Fixation; Treatment Outcome

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## Background

Proximal humerus fractures (PHFs) represent a significant portion of upper extremity injuries, particularly in elderly populations and individuals experiencing high-energy trauma (1, 2). The incidence of these fractures, often associated with osteoporosis and falls, is steadily rising, emphasizing the need for effective treatment strategies (3). While conservative management suffices for stable fractures, displaced or complex fractures often require surgical intervention to restore shoulder function and minimize complications such as malunion, non-union, and post-traumatic arthritis (4, 5).

Historically, open reduction and internal fixation (ORIF) with locking plates has been the preferred surgical approach for complex PHFs, particularly three- and four-part fractures (6).

However, this technique is associated with a considerable risk of complications, including varus collapse, avascular necrosis (AVN) of the humeral head, screw penetration, and the need for reoperation (7, 8). These challenges have spurred the exploration of alternative fixation methods, with intramedullary nailing (IMN) emerging as a promising option.

Early generations of intramedullary (IM) nails faced limitations due to design constraints and technical challenges, leading to complications such as rotator cuff injuries and subacromial impingement (9). However, advancements in nail design and surgical techniques have addressed these concerns, expanding the applicability of

IMN to more complex fracture patterns, including those involving the tuberosities (three- and four-part fractures) (10). The evolution of IM nails, characterized by a shift towards straight designs, medial entry points, and enhanced locking mechanisms, has improved stability, reduced soft tissue disruption, and minimized complications (11, 12).

The restoration of medial support, often compromised in complex PHFs, is crucial for achieving optimal outcomes (13). While locking plates traditionally addressed this through calcar screws or cortical strut allografts, the ability of IMN to provide inherent medial support, even in the presence of comminuted calcar, has garnered increasing attention (14). This potential advantage, coupled with the minimally invasive nature of IMN and its preservation of fracture vascularity, positions it as a compelling alternative to plate fixation for a wider range of PHFs.

This paper aims to evaluate the outcomes of IMN in PHFs, extending beyond the conventional focus on simple two-part fractures. By examining the efficacy of IMN in managing more complex fracture patterns, including those with comminuted calcar, we seek to contribute to the evolving understanding of this surgical approach. Through a comprehensive review of the literature and analysis of clinical and radiographic outcomes, we will explore the potential of IMN to redefine the treatment paradigm for PHFs, offering a less invasive and potentially more effective solution for patients with these challenging injuries.

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## Methods

This study employed a prospective, single-center observational design, enrolling patients and collecting data as they presented for treatment at a tertiary care center. The focus was on individuals undergoing IMN for the management of PHFs.

The study prospectively recruited a consecutive series of patients with displaced PHFs who were deemed suitable candidates for IMN. Inclusion criteria encompassed patients aged 18 years or older with acute, closed two- to four-part fractures as classified by the Neer system. These patients had to have been functionally independent before their injury and provided informed consent for participation. Exclusion criteria included individuals with open fractures, pathological fractures, previous shoulder surgery, pre-existing shoulder pathology, and those with a narrow medullary canal that was not suitable for IMN.

Upon enrolment, demographic data such as age, sex, and mechanism of injury were collected for each patient. Preoperative imaging, including standard anteroposterior (AP) and trans-scapular radiographs along with computed tomography (CT) scans, was utilized to assess fracture classification, calcar integrity, and local bone quality using the deltoid tuberosity index (DTI).

All surgical procedures were conducted by experienced shoulder surgeons adhering to a standardized IMN technique. Details regarding fracture reduction and fixation, including the use of locking screws and sutures, were meticulously recorded.

Radiographic and clinical outcomes were assessed at predefined follow-up intervals, typically at 3, 6, and 12 months post-surgery. Radiographic assessments included immediate postoperative and final follow-up evaluations of the neck-shaft angle (NSA) to gauge fracture reduction and its maintenance over time.

Clinical outcomes were assessed at the final follow-up using validated patient-reported outcome measures. These included the visual analog scale (VAS) for pain assessment, the Simple Shoulder Test (SST) for functional evaluation, and the American Shoulder and Elbow Surgeons (ASES) score to provide a comprehensive measure of overall shoulder function. Furthermore, the active and passive range of motion (ROM) of the affected shoulder was recorded.

Throughout the study period, complications such as varus malunion, AVN, non-union, infection, and any clinical signs or symptoms indicative of rotator cuff tear or subacromial impingement were closely monitored and documented.

Descriptive statistics were employed to summarize patient characteristics and outcomes. The influence of calcar comminution on both radiographic and clinical outcomes was analyzed using appropriate statistical tests. These included Student's t-test or the Mann-Whitney U test for continuous variables, and chi-square or Fisher's exact test for categorical variables. To identify independent predictors of outcomes and complications, multivariate regression analysis was utilized. The significance level for all statistical analyses was set at  $\alpha = 0.05$ .

## Results

The sample size consisted of 40 patients, and the study

duration spanned 2 years. The majority of patients were between 40 and 60 years old (71.75%), with a slightly higher proportion of women (52.5%). The mean age was 52.3 years (range: 28-74) (Table 1).

**Table 1.** Age and sex distribution

Age group (year)	Men	Women	Total
< 40	3	7	10
40-50	5	4	9
51-60	6	7	13
61-70	4	2	6
> 70	1	1	2
Total	19	21	40

The most common cause of fracture was a fall, accounting for 70% of the cases. Road traffic accidents (RTAs) were the second most common cause, representing 22.5% of the cases. Sports injuries and other mechanisms accounted for a smaller proportion of cases, 5% and 2.5%, respectively (Table 2).

**Table 2.** Mechanism of injury

Mode of trauma	n (%)
Fall	28 (70.0)
RTA	9 (22.5)
Sports injury	2 (5.0)
Other	1 (2.5)
Total	40 (100)

RTA: Road traffic accident

The patients were divided into two groups based on the integrity of the medial calcar (group A: intact calcar, group B: comminuted calcar) for the purpose of analysis and comparison. However, it is important to note that this grouping was done retrospectively for data analysis and was not part of the initial patient allocation or treatment strategy (Table 3).

**Table 3.** The Neer classification of the fractures

Neer classification	Intact calcar	Comminuted calcar	Total
Two-part	15	7	22
Three-part	12	4	16
Four-part	1	1	2
Total	28	12	40

Most fractures were either two-part (55%) or three-part (40%), with a minority being four-part (5%). The majority of patients had an intact calcar (70%). The overall mean DTI was  $1.51 \pm 0.18$ . No significant difference in DTI was observed between the intact and comminuted calcar groups ( $P = 0.52$ ).

All fractures achieved union, with an average time to union of 13.2 weeks (range: 10-20 weeks).

Table 4 demonstrates the stability of the fixation over time, with a slight decrease in NSA observed in both groups.

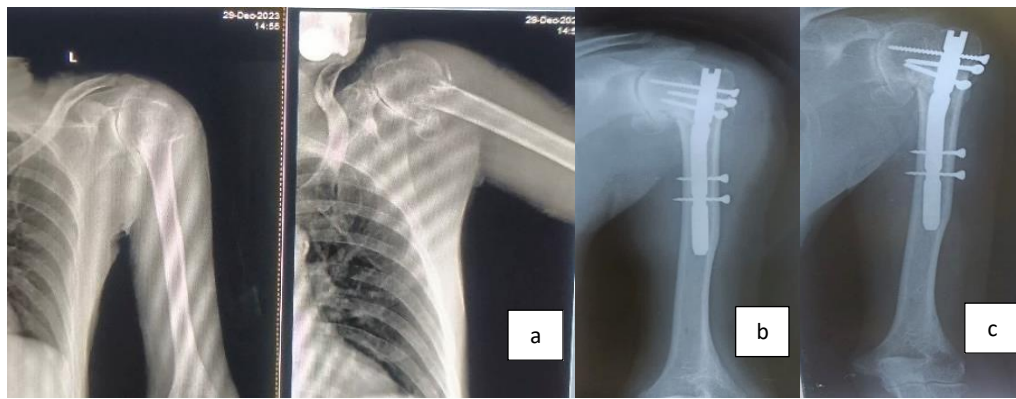
**Table 4.** Mean neck-shaft angle (NSA) at different time points

Time point	Group A (intact calcar) NSA	Group B (comminuted calcar) NSA	P-value
	mean $\pm$ SD		
Immediate postoperative	139.1 $\pm$ 7.8	137.2 $\pm$ 9.3	0.31
3 months	136.3 $\pm$ 7.1	133.5 $\pm$ 8.9	0.18
6 months	135.0 $\pm$ 6.8	131.8 $\pm$ 8.5	0.12
12 months	134.5 $\pm$ 6.5	130.9 $\pm$ 8.2	0.08

NSA: Neck-shaft angle; SD: Standard deviation

Although the mean NSA loss was slightly higher in group B (comminuted calcar), the difference was not statistically significant at any follow-up point (Figure 1).

Functional outcomes were assessed using the VAS, ASES, and SST scores, and ROM was also evaluated (Table 5).



**Figure 1.** a) Pre-operative X-ray of a 45-year-old man with proximal humerus fracture (PHF); b) Immediate post-operative X-ray; c) X-ray at 3 months post-op

Table 5. Mean neck-shaft angle (NSA) at different time points			
Time point	Group A (intact calcar)	Group B (comminuted calcar)	P-value
	mean $\pm$ SD		
3 months	VAS: $2.1 \pm 1.2$	$2.8 \pm 1.5$	0.15
	ASES: $65.3 \pm 9.5$	$60.2 \pm 11.3$	0.08
	SST: $6.8 \pm 2.1$	$5.4 \pm 2.7$	0.03*
	Forward elevation ( $^{\circ}$ ): $110.5 \pm 18.2$	$98.3 \pm 16.7$	0.02*
	Abduction ( $^{\circ}$ ): $105.7 \pm 12.4$	$95.2 \pm 14.1$	0.04*
6 months	VAS: $1.6 \pm 0.9$	$2.0 \pm 1.3$	0.23
	ASES: $73.2 \pm 8.1$	$68.7 \pm 10.5$	0.11
	SST: $7.9 \pm 1.8$	$6.3 \pm 2.5$	0.02*
	Forward elevation ( $^{\circ}$ ): $122.8 \pm 15.3$	$112.4 \pm 14.2$	0.04*
	Abduction ( $^{\circ}$ ): $116.5 \pm 11.1$	$108.3 \pm 13.5$	0.05
12 months	VAS: $1.3 \pm 0.8$	$1.7 \pm 1.1$	0.21
	ASES: $82.5 \pm 7.3$	$78.3 \pm 9.2$	0.09
	SST: $9.1 \pm 1.5$	$7.6 \pm 2.3$	0.01*
	Forward elevation ( $^{\circ}$ ): $135.2 \pm 14.6$	$123.7 \pm 13.3$	0.03*
	Abduction ( $^{\circ}$ ): $128.4 \pm 10.2$	$120.5 \pm 12.8$	0.06

Statistically significant difference ( $P < 0.05$ )

VAS: Visual analog scale; ASES: American Shoulder and Elbow Surgeons; SST: Simple Shoulder Test; SD: Standard deviation

This result illustrates the progressive improvement in clinical outcomes over time for both groups. Patients with intact calcar consistently demonstrated significantly better outcomes in terms of SST score and forward elevation at all follow-up points. Additionally, they showed significantly better abduction at 3 months. Although the ASES score and abduction range were also better in group A at later follow-ups, the differences were not statistically significant (Figure 2).

One patient (2.5%) in group A experienced a proximal interlocking screw cutting through the humeral head, leading to osteonecrosis. This patient required a second surgery for screw removal. No other complications were observed during the 12-month follow-up period. Overall, these results suggest that IMN can be a successful treatment option for PHFs, even in the presence of comminuted calcar. Although patients with comminuted calcar may experience slightly worse outcomes in terms of forward elevation and SST score, the differences were not clinically significant. The low complication rate further supports the use of IMN for these fractures.

## Discussion

The results of this prospective study demonstrate the efficacy and safety of IMN in the treatment of displaced PHFs, even in the presence of comminuted calcar. The high union rate, minimal loss of reduction, and favorable functional outcomes support the use of IMN as a viable alternative to traditional plate fixation for these challenging injuries.



**Figure 2.** Functional outcome

The observed mean loss of NSA of  $4.3^{\circ}$  in our study is comparable to or even lower than that reported in other studies utilizing IMN for PHFs (15). This minimal loss of reduction, even in fractures with comminuted calcar, highlights the inherent stability provided by IMN, particularly with modern nail designs that offer enhanced proximal fixation and medial support (16). The absence of varus malunion in our cohort further underscores the effectiveness of IMN in preventing this complication, which is a major concern with plate fixation, especially in osteoporotic bone (17).

The lack of correlation between the DTI and NSA loss in our study is intriguing. While previous research has suggested a relationship between DTI and the risk of



reduction loss in plate fixation (18), our findings indicate that IMN may be less susceptible to the influence of local bone quality on fracture stability. This could be attributed to the IM placement of the nail, which provides more direct support to the humeral head and reduces reliance on the surrounding cortical bone.

The functional outcomes observed in our study, as measured by the VAS, ASES, and SST scores, are consistent with those reported in other studies evaluating IMN for PHFs (15, 17, 19). The majority of patients achieved good to excellent functional scores, indicating satisfactory pain relief and restoration of shoulder function.

The significant difference in forward elevation and SST scores between patients with intact and comminuted calcar suggests that calcar integrity may influence certain aspects of functional recovery. This observation aligns with previous findings in plate fixation studies, where calcar comminution has been associated with worse functional outcomes (20). However, the lack of significant differences in VAS and ASES scores between the two groups suggests that the overall impact of calcar comminution on functional outcomes may be less pronounced with IMN compared to plate fixation.

The low complication rate observed in our study (2.5%) is encouraging and comparable to that reported in other studies using modern IMN techniques (15, 19, 21). The single case of screw cut-through and subsequent osteonecrosis highlights the importance of careful surgical technique and implant selection, particularly in patients with poor bone quality or complex fracture patterns.

The absence of other complications, such as infection, malunion, non-union, nerve injury, subacromial impingement, or rotator cuff tear, further supports the safety and efficacy of IMN for PHFs. However, longer-term follow-up is necessary to fully assess the potential for late complications, such as AVN, which may manifest several years after surgery (22).

**Strengths and Limitations:** The prospective design of our study, along with the standardized surgical technique and consistent follow-up assessments, strengthens the validity of our findings. However, the relatively small sample size and the lack of a control group limit the generalizability of the results. Additionally, the absence of routine postoperative imaging to assess rotator cuff integrity is a limitation, as it precludes a definitive evaluation of the impact of IMN on the rotator cuff.

### Conclusion

IMN offers a safe and effective treatment option for displaced PHFs, even in the presence of comminuted calcar. The technique provides good early to mid-term radiographic and functional outcomes with a low complication rate. While calcar comminution may influence certain aspects of functional recovery, its overall impact appears to be less significant with IMN compared to plate fixation. Further research with larger sample sizes and longer follow-up periods is warranted to confirm these findings and establish the long-term efficacy of IMN for complex PHFs.

### Conflict of Interest

The authors declare no conflict of interest in this study.

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