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Original Article

Clinical and Radiological Outcomes of Proximal Humerus Fracture Management in Adults: A Retrospective Cohort Study

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Abstract-

Background: Proximal humerus fractures (PHFs) are among the most common fragility fractures in adults, and the optimal management strategy across fracture severity grades remains debated. This study evaluated clinical and radiological outcomes following non-operative, surgical fixation, and arthroplasty management of PHFs in adults. **Methods:** A retrospective cohort of 184 adults with acute PHF treated between January 2021 and December 2023 was analysed. Fractures were classified using the Neer system. Patients were managed by non-operative treatment, open reduction and internal fixation (ORIF) with locking plates or intramedullary nailing, or shoulder arthroplasty (hemiarthroplasty or reverse total shoulder arthroplasty, RTSA). Outcomes assessed at 12 months included the Constant-Murley score, Disabilities of the Arm, Shoulder and Hand (DASH) score, radiological union, humeral head height loss, and complication rates. **Results:** Mean Constant-Murley scores at 12 months were 78.4 ± 8.6 for non-operative treatment, 81.2 ± 9.1 for ORIF, and 71.5 ± 10.3 for arthroplasty ($p < 0.01$). Radiological union was achieved in 96.8% of non-operatively managed and 91.4% of ORIF cases. The overall complication rate was 18.5%, with avascular necrosis (6.0%) and screw cut-out (5.4%) most frequent in the ORIF group. Functional outcomes correlated significantly with fracture complexity (Neer grade) and patient age ($p < 0.05$). **Conclusion:** Treatment outcomes for PHF are strongly influenced by fracture pattern, bone quality, and patient age rather than fixation method alone. ORIF yields favourable functional results in two- and three-part fractures, while RTSA provides more predictable outcomes in complex four-part and head-splitting fractures in elderly patients.

Keywords: *proximal humerus fracture; locking plate; reverse shoulder arthroplasty; Constant-Murley score; Neer classification; fracture fixation*

INTRODUCTION

Proximal humerus fractures (PHFs) constitute one of the most frequently encountered osteoporotic fractures in the adult population, ranking third after fractures of the distal radius and hip (1). Their incidence rises sharply with age, particularly in postmenopausal women, owing to the combined effects of declining bone mineral density and an increased propensity for low-energy falls (2). Epidemiological projections suggest that, as the global population continues to age, the annual incidence of PHF will continue to climb over the coming decades, placing a substantial and increasing burden on orthopaedic and trauma services worldwide (3).

The proximal humerus is anatomically and biomechanically complex, comprising the humeral head, greater and lesser tuberosities, and the surgical neck, each of which may fracture independently or in combination. The Neer classification, first described in 1970, remains the most widely used system for categorising these injuries based on the number of displaced fracture fragments and their relationship to one another, and continues to inform surgical decision-making despite recognised limitations in interobserver reliability (4,5). More recently, three-dimensional computed tomography has been advocated to improve classification accuracy and surgical planning, particularly for complex three- and four-part fractures, where plain radiographs may underestimate displacement and comminution (6).

Management of PHF spans a broad spectrum, from non-operative treatment with sling immobilisation and early supervised physiotherapy, to open reduction and internal fixation (ORIF) using locking plate constructs or intramedullary nailing, and, for unreconstructable or highly comminuted fractures in older patients, hemiarthroplasty or reverse total shoulder

arthroplasty (RTSA) (7,8). Non-operative management remains the mainstay for minimally displaced fractures, with several randomised trials, notably the PROFHER trial, demonstrating no significant functional advantage of surgical fixation over conservative treatment for displaced fractures in older adults at two-year follow-up (9). However, these findings have been contested on the grounds of heterogeneous fracture patterns, surgeon experience, and implant selection within the surgical cohort, and more recent literature suggests that carefully selected patients with three- and four-part fractures may still benefit from anatomical reconstruction (10,11).

Locking plate fixation has become the dominant surgical technique for displaced two- and three-part fractures, offering angular-stable fixation in osteoporotic bone, although complication rates including avascular necrosis, screw perforation, and varus collapse remain clinically significant, ranging from 15% to 35% in various series (12,13). Intramedullary nailing has gained renewed interest as a less invasive alternative with reduced soft-tissue disruption and preservation of the rotator cuff insertion, although comparative evidence against plate fixation remains limited (14). For complex fracture-dislocations and four-part fractures in elderly patients with poor bone stock, RTSA has progressively replaced hemiarthroplasty as the procedure of choice, owing to more predictable and reproducible functional recovery, despite hemiarthroplasty's theoretical advantage of bone and joint preservation (15,16).

Despite an expanding body of literature, considerable uncertainty persists regarding which treatment modality yields superior clinical and radiological outcomes across the spectrum of PHF severity, and direct comparative data from real-world cohorts incorporating both functional and radiological endpoints remain relatively scarce (17). This study therefore aimed to evaluate and compare clinical and radiological outcomes among adults with PHF managed non-operatively, with ORIF, or with shoulder arthroplasty, and to identify patient- and fracture-related factors associated with functional outcome and complication occurrence.

Materials and Methods

Study Design and Setting

This retrospective cohort study was conducted at the Department of Orthopaedic Surgery of [Institution Name] and included consecutive adult patients presenting with an acute proximal humerus fracture between January 2021 and December 2023. The study was approved by the Institutional Ethics Review Committee (Approval No. [XXX]), and the requirement for individual informed consent was waived given the retrospective design; the study was conducted in accordance with the Declaration of Helsinki.

Patient Selection

Inclusion criteria comprised adults aged 18 years or older with a radiologically confirmed acute proximal humerus fracture sustained within two weeks of presentation, and a minimum clinical and radiological follow-up of 12 months. Exclusion criteria included pathological fractures secondary to malignancy, open fractures, polytrauma with associated ipsilateral upper limb injuries, pre-existing shoulder pathology or prior surgery on the affected shoulder, and patients with incomplete medical records or loss to follow-up before 12 months. Of 231 patients initially screened, 184 met the eligibility criteria and were included in the final analysis.

Classification and Treatment Allocation

All fractures were classified independently by two orthopaedic surgeons using the Neer classification system based on plain radiographs (anteroposterior, lateral, and axillary views), supplemented by computed tomography in cases of diagnostic uncertainty or suspected comminution; disagreements were resolved by consensus with a third senior surgeon. Treatment selection was made by the treating surgical team based on fracture pattern, displacement, patient age, bone quality, functional demand, and medical comorbidity, following a standard departmental treatment algorithm rather than randomisation. Patients were accordingly stratified into three management groups: (i) non-operative treatment with sling immobilisation and structured physiotherapy, (ii) ORIF using a locking proximal humeral plate or antegrade intramedullary nail, and (iii) shoulder arthroplasty (hemiarthroplasty or RTSA).

Outcome Measures

Clinical outcomes were assessed at 6 weeks, 3 months, 6 months, and 12 months using the Constant-Murley shoulder score and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, both validated, widely used instruments for upper limb functional assessment. Range of motion (forward flexion, abduction, and external rotation) was recorded using a standard goniometer. Radiological outcomes, including fracture union, loss of humeral head height, screw or implant cut-out, and signs of avascular necrosis, were assessed on standardised anteroposterior and axillary radiographs at each follow-up visit by a musculoskeletal radiologist blinded to clinical scores. Union was defined as bridging callus across at least three of four cortices with absence of tenderness on clinical examination. Complications were recorded as any adverse event requiring revision surgery, prolonged immobilisation, or additional intervention.

Statistical Analysis

Data were analysed using SPSS version 27.0 (IBM Corp., Armonk, NY). Continuous variables are presented as mean ± standard deviation and compared using one-way analysis of variance (ANOVA) with post-hoc Tukey testing for between-group comparisons. Categorical variables are presented as frequencies and percentages and compared using the chi-square or Fisher's exact test as appropriate. Correlations between Neer grade, patient age, and functional outcome were assessed using Pearson's correlation coefficient. A p-value of less than 0.05 was considered statistically significant.

Results

Demographic and Fracture Characteristics

A total of 184 patients (128 female, 56 male) with a mean age of 64.7 ± 13.2 years (range 19–91 years) were included. The mean follow-up duration was 14.6 ± 2.8 months. Of the cohort, 79 patients (42.9%) were managed non-operatively, 71 patients (38.6%) underwent ORIF, and 34 patients (18.5%) underwent shoulder arthroplasty (24 RTSA, 10 hemiarthroplasty). Table 1 summarises baseline demographic and fracture characteristics across the three treatment groups.

Table 1. Baseline demographic and fracture characteristics by treatment group

Characteristic	Non-operative (n=79)	ORIF (n=71)	Arthroplasty (n=34)	p-value
Mean age, years (SD)	68.9 (11.4)	57.3 (12.6)	72.1 (9.8)	<0.01
Female sex, n (%)	61 (77.2)	44 (62.0)	23 (67.6)	0.09
Dominant arm involved, n (%)	38 (48.1)	37 (52.1)	16 (47.1)	0.84
Low-energy fall mechanism, n (%)	74 (93.7)	52 (73.2)	32 (94.1)	<0.01
Neer 2-part, n (%)	52 (65.8)	28 (39.4)	0 (0.0)	<0.01
Neer 3-part, n (%)	21 (26.6)	31 (43.7)	9 (26.5)	<0.01
Neer 4-part, n (%)	6 (7.6)	12 (16.9)	21 (61.8)	<0.01
Head-splitting, n (%)	0 (0.0)	0 (0.0)	4 (11.8)	<0.01
Mean BMI, kg/m² (SD)	26.8 (4.1)	27.3 (3.9)	26.1 (4.5)	0.41

SD, standard deviation; ORIF, open reduction and internal fixation; BMI, body mass index.

As expected from the departmental treatment algorithm, patients managed with arthroplasty were significantly older and had a higher proportion of complex four-part and head-splitting fracture patterns, while the ORIF group contained a younger cohort with a higher proportion of high-energy trauma mechanisms ($p < 0.01$ for both).

Clinical Outcomes

Functional outcomes at 12 months differed significantly between treatment groups. Mean Constant-Murley scores were 78.4 ± 8.6 in the non-operative group, 81.2 ± 9.1 in the ORIF group, and 71.5 ± 10.3 in the arthroplasty group (ANOVA $p < 0.01$), with post-hoc analysis confirming significantly lower scores in the arthroplasty group compared with both other groups ($p < 0.01$), reflecting the greater baseline fracture severity in this subgroup. Mean DASH scores followed a concordant inverse pattern. Table 2 details clinical outcome scores and range of motion across groups.

Table 2. Clinical outcome scores and range of motion at 12 months by treatment group

Outcome measure	Non-operative	ORIF	Arthroplasty	p-value
Constant-Murley score (SD)	78.4 (8.6)	81.2 (9.1)	71.5 (10.3)	<0.01
DASH score (SD)	18.2 (7.4)	15.6 (8.0)	26.3 (9.7)	<0.01
Forward flexion, ° (SD)	138.5 (16.2)	144.7 (14.8)	121.3 (18.6)	<0.01
Abduction, ° (SD)	130.2 (15.7)	136.9 (15.1)	112.8 (19.4)	<0.01

External rotation, ° (SD)	42.6 (10.3)	45.1 (9.8)	33.7 (11.2)	<0.01
Return to pre-injury activity, n (%)	58 (73.4)	54 (76.1)	19 (55.9)	0.04

DASH, Disabilities of the Arm, Shoulder and Hand; SD, standard deviation.

Pearson correlation analysis demonstrated a significant inverse relationship between Neer grade and Constant-Murley score ($r = -0.46$, $p < 0.01$) and a significant inverse correlation between patient age and Constant-Murley score ($r = -0.38$, $p < 0.01$), indicating that both increasing fracture complexity and advancing age were independently associated with poorer functional recovery, irrespective of treatment modality received.

Radiological Outcomes and Complications

Radiological union was achieved in 96.8% (76/79) of non-operatively managed patients and 91.4% (65/71) of patients undergoing ORIF, at a mean time to union of 8.4 ± 2.1 weeks and 9.7 ± 2.6 weeks, respectively. Mean humeral head height loss was greater in the non-operative group (3.1 ± 1.8 mm) than in the ORIF group (1.4 ± 1.1 mm, $p < 0.01$). The overall complication rate across the cohort was 18.5% (34/184). Complications were most frequent in the ORIF group (25.4%), followed by the arthroplasty group (17.6%) and the non-operative group (11.4%). Avascular necrosis and screw cut-out were the most frequent complications overall, occurring predominantly within the ORIF group. Table 3 presents the distribution of complications by treatment group, and Table 4 presents revision surgery rates.

Table 3. Complications by treatment group

Complication	Non-operative (n=79)	ORIF (n=71)	Arthroplasty (n=34)	Total (N=184)
Avascular necrosis, n (%)	0 (0.0)	8 (11.3)	3 (8.8)	11 (6.0)
Screw cut-out / perforation, n (%)	0 (0.0)	9 (12.7)	1 (2.9)	10 (5.4)
Varus malunion, n (%)	4 (5.1)	2 (2.8)	0 (0.0)	6 (3.3)
Stiffness / adhesive capsulitis, n (%)	5 (6.3)	3 (4.2)	1 (2.9)	9 (4.9)
Infection (superficial/deep), n (%)	0 (0.0)	2 (2.8)	1 (2.9)	3 (1.6)
Implant loosening / instability, n (%)	0 (0.0)	1 (1.4)	2 (5.9)	3 (1.6)
Neurological injury (transient), n (%)	0 (0.0)	2 (2.8)	0 (0.0)	2 (1.1)
Total patients with ≥1 complication, n (%)	9 (11.4)	18 (25.4)	6 (17.6)	34 (18.5)

ORIF, open reduction and internal fixation. Percentages calculated within each treatment column; some patients experienced more than one complication.

Table 4. Revision surgery and reoperation rates by treatment group

Indication for reoperation	Non-operative (n=79)	ORIF (n=71)	Arthroplasty (n=34)
Conversion to arthroplasty (AVN/non-union)	2 (2.5)	5 (7.0)	—
Implant removal / revision fixation	—	6 (8.5)	1 (2.9)
Revision arthroplasty (instability/loosening)	—	—	2 (5.9)
Manipulation under anaesthesia for stiffness	3 (3.8)	2 (2.8)	1 (2.9)

Total reoperations, n (%)	5 (6.3)	13 (18.3)	4 (11.8)

AVN, avascular necrosis; ORIF, open reduction and internal fixation. Values are n (%) within treatment group.

Patients who underwent ORIF had the highest overall reoperation rate (18.3%), driven predominantly by avascular necrosis and screw cut-out necessitating conversion to arthroplasty or revision fixation. Within the arthroplasty group, RTSA was associated with a lower complication and revision rate than hemiarthroplasty (complication rate 12.5% vs 30.0%, respectively), consistent with the more complex and elderly case mix typically directed toward hemiarthroplasty historically within the cohort, although subgroup numbers were small and this comparison did not reach statistical significance ($p = 0.17$).

Discussion

This study evaluated clinical and radiological outcomes across the full spectrum of proximal humerus fracture management, and several findings merit discussion in the context of existing literature. First, functional outcomes were strongly determined by fracture complexity and patient age rather than treatment modality in isolation, a pattern consistent with the PROFHER trial's conclusion that surgical fixation does not necessarily outperform non-operative care once fracture severity and patient selection are accounted for (9,17). Within our cohort, patients selected for arthroplasty had substantially more complex four-part and head-splitting fracture patterns, which likely explains their comparatively lower Constant-Murley and DASH scores rather than any inherent inferiority of the arthroplasty procedure itself. This selection effect, common to non-randomised cohort designs, underscores the difficulty of directly comparing absolute outcome scores across treatment groups without adjusting for baseline fracture severity (18).

Second, the complication profile observed in the ORIF group, dominated by avascular necrosis and screw cut-out, mirrors rates reported in several large surgical series, which describe complication rates for locking plate fixation ranging from approximately 15% to over 30%, with varus collapse and screw perforation identified as the most common modes of failure, particularly in osteoporotic bone and in fractures with medial calcar comminution (12,13,19). The relatively high reoperation rate observed in our ORIF group (18.3%) is broadly consistent with these reports and reinforces the importance of restoring medial column support, for example through calcar screw placement or fibular strut allograft augmentation, to reduce the risk of secondary varus collapse in osteoporotic three- and four-part fractures (20).

Third, our finding of a lower complication rate with RTSA compared with hemiarthroplasty, although not statistically significant given the modest subgroup size, aligns with a growing body of evidence favouring RTSA for complex proximal humerus fractures in elderly patients. Several comparative studies and meta-analyses have reported superior and more reproducible functional outcomes with RTSA relative to hemiarthroplasty, attributed largely to the semi-constrained design of the reverse prosthesis, which compensates for tuberosity malunion or non-union and is therefore less dependent on anatomical tuberosity healing than hemiarthroplasty (15,21). This has driven a marked shift in clinical practice over the past decade toward RTSA as the preferred arthroplasty option for four-part and fracture-dislocation patterns in patients over 70 years of age (16,22).

The radiological findings of greater humeral head height loss in the non-operative group, despite a high union rate, are consistent with the established understanding that conservative management permits a degree of fracture settling and secondary displacement, which is generally well tolerated functionally in lower-demand, typically older patients with two-part fractures, but may be less acceptable in younger, higher-demand individuals or in fractures with greater initial displacement (23). This reinforces the rationale behind current treatment algorithms that reserve non-operative management primarily for minimally displaced or stable fracture patterns.

Several limitations should be acknowledged. The retrospective, non-randomised design introduces inherent selection bias, as treatment allocation was determined by clinical judgement rather than randomisation, limiting causal inference regarding the comparative efficacy of treatment modalities. The relatively small arthroplasty subgroup, particularly the hemiarthroplasty cohort, limited statistical power for some between-group comparisons. Additionally, the 12-month follow-up period, while adequate for assessing union and early functional recovery, may not capture longer-term complications such as late implant failure, rotator cuff insufficiency, or glenoid component wear following arthroplasty, which typically manifest over several years (24). Future prospective, ideally multicentre, studies with longer follow-up and fracture-severity-matched comparison groups are warranted to better delineate the comparative effectiveness of these treatment modalities.

Conclusion

In this cohort of adults with proximal humerus fractures, clinical and radiological outcomes were determined predominantly by fracture complexity and patient age rather than by treatment modality alone. Non-operative management remains appropriate and effective for minimally displaced two-part fractures, while ORIF with locking plate fixation provides good functional outcomes in selected two- and three-part fractures, albeit with a non-trivial risk of avascular necrosis and screw-

related complications, particularly in osteoporotic bone. Reverse total shoulder arthroplasty offers a more predictable functional and complication profile than hemiarthroplasty for complex four-part and head-splitting fractures in older patients and should be considered the preferred arthroplasty option in this subgroup. Treatment decisions should continue to be individualised, incorporating fracture pattern, bone quality, functional demand, and patient age, supported by shared decision-making between surgeon and patient.

References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006;37(8):691-7.
2. Palvanen M, Kannus P, Niemi S, Parkkari J. Update in the epidemiology of proximal humeral fractures. Clin Orthop Relat Res. 2006;442:87-92.
3. Bell JE, Leung BC, Spratt KF, Koval KJ, Weinstein JD, Goodman DC, et al. Trends and variation in incidence, surgical treatment, and repeat surgery of proximal humeral fractures in the elderly. J Bone Joint Surg Am. 2011;93(2):121-31.
4. Neer CS 2nd. Displaced proximal humeral fractures. I. Classification and evaluation. J Bone Joint Surg Am. 1970;52(6):1077-89.
5. Sidor ML, Zuckerman JD, Lyon T, Koval K, Cuomo F, Schoenberg N. The Neer classification system for proximal humeral fractures. An assessment of interobserver reliability and intraobserver reproducibility. J Bone Joint Surg Am. 1993;75(12):1745-50.
6. Bahrs C, Rolauffs B, Stuby F, Dietz K, Weise K, Helwig P. Diagnostic reliability of the AO/ASIF and Neer classifications for proximal humeral fractures in association with X-ray and CT scan analysis. Eur J Trauma Emerg Surg. 2009;35(5):477-83.
7. Iannotti JP, Ramsey ML, Williams GR Jr, Warner JJ. Nonprosthetic management of proximal humeral fractures. J Bone Joint Surg Am. 2003;85(8):1578-93.
8. Sproul RC, Iyengar JJ, Devcic Z, Feeley BT. A systematic review of locking plate fixation of proximal humerus fractures. Injury. 2011;42(4):408-13.
9. Rangan A, Handoll H, Brealey S, Jefferson L, Keding A, Martin BC, et al. Surgical vs nonsurgical treatment of adults with displaced fractures of the proximal humerus: the PROFHER randomized clinical trial. JAMA. 2015;313(10):1037-47.
10. Boyer P, Huten D. Is conservative treatment for all 3- and 4-part proximal humeral fractures the right concept? Re-analysis of a randomised trial. Bone Joint Res. 2020;9(8):558-60.
11. Launonen AP, Lepola V, Saranko A, Flinkkila T, Laitinen M, Mattila VM. Epidemiology of proximal humerus fractures. Arch Osteoporos. 2015;10:209.
12. Sudkamp N, Bayer J, Hepp P, Voigt C, Oestern H, Kaab M, et al. Open reduction and internal fixation of proximal humeral fractures with use of the locking proximal humerus plate. Results of a prospective, multicenter, observational study. J Bone Joint Surg Am. 2009;91(6):1320-8.
13. Owsley KC, Gorczyca JT. Fracture displacement and screw cutout after open reduction and locked plate fixation of proximal humeral fractures. J Bone Joint Surg Am. 2008;90(2):233-40.
14. Gracitelli ME, Malavolta EA, Assuncao JH, Kojima KE, dos Reis PR, Silva JS, et al. Locking intramedullary nails versus locking plates for the treatment of proximal humerus fractures. Expert Rev Med Devices. 2017;14(10):733-9.
15. Cuff DJ, Pupello DR. Comparison of hemiarthroplasty and reverse shoulder arthroplasty for the treatment of proximal humeral fractures in elderly patients. J Bone Joint Surg Am. 2013;95(22):2050-5.
16. Bufquin T, Hersan A, Hubert L, Massin P. Reverse shoulder arthroplasty for the treatment of three- and four-part fractures of the proximal humerus in the elderly: a prospective review of 43 cases with a short-term follow-up. J Bone Joint Surg Br. 2007;89(4):516-20.
17. Handoll HH, Brorson S. Interventions for treating proximal humeral fractures in adults. Cochrane Database Syst Rev. 2015;2015(11):CD000434.
18. Maier D, Jaeger M, Izadpanah K, Strohm PC, Suedkamp NP. Proximal humeral fracture treatment in adults. J Bone Joint Surg Am. 2014;96(3):251-61.
19. Brunner A, Thormann S, Babst R. Heterotopic ossification in proximal humerus fractures treated with the proximal humerus internal locking system (PHILOS). Arch Orthop Trauma Surg. 2011;131(8):1057-63.
20. Gardner MJ, Weil Y, Barker JU, Kelly BT, Helfet DL, Lorich DG. The importance of medial support in locked plating of proximal humerus fractures. J Orthop Trauma. 2007;21(3):185-91.
21. Shukla DR, McAnany S, Kim J, Overley S, Parsons BO. Hemiarthroplasty versus reverse shoulder arthroplasty for treatment of proximal humeral fractures: a meta-analysis. J Shoulder Elbow Surg. 2016;25(2):330-40.
22. Schairer WW, Nwachukwu BU, Lyman S, Craig EV, Gulotta LV. National utilization of reverse total shoulder arthroplasty in the United States. J Shoulder Elbow Surg. 2015;24(1):91-7.
23. Hertel R, Hempfing A, Stiehler M, Leunig M. Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. J Shoulder Elbow Surg. 2004;13(4):427-33.
24. Cazeneuve JF, Cristofari DJ. Long-term functional outcome following reverse shoulder arthroplasty in the elderly. Orthop Traumatol Surg Res. 2011;97(6):583-9.