

MANAGEMENT OF PROXIMAL HUMERUS FRACTURES IN ADULTS

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ABSTRACT

Introduction: Proximal humerus fractures, more common in women and increasingly prevalent with age due to falls, pose a challenge in orthopaedic care, often leading to persistent pain and reduced shoulder function. This systematic review aims to evaluate diverse management strategies for these fractures in adults, analysing their effectiveness, complications, and patient-reported outcomes to guide treatment decisions.

Methods: The researchers in this study followed the 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines to ensure that their work met the required standards. This was done to ensure the precision and reliability of the conclusions derived from the research.

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Result Our search produced 13 results. After looking at the titles and summaries, we found several papers that fit our criteria. At first, we excluded few articles because they were written in review and case report style. But after reading the full papers carefully, we included five papers in our final analysis. These papers included prospective, retrospective studies, and prospective randomized control trial study.

Conclusion: This comprehensive study compared ORIF, HA, and RSA in PHF patients, revealing that ORIF was preferred in younger patients with simpler fractures, while RSA was favoured in older patients with complex fractures. ORIF demonstrated better motion than HA, but higher reoperation rates were noted for ORIF and HA compared to RSA, essential information for patient discussions. Postoperative fractures were prevalent, highlighting a need for counselling to prevent future falls and fractures post-PHF treatment. Despite prior inconclusive studies, the need to reduce unnecessary surgeries, especially in the elderly, remains crucial to minimize complications and healthcare costs amidst the shifting treatment landscape.

Keywords: Hemiarthroplasty, proximal humerus fracture, ORIF, Reverse Shoulder Arthroplasty

INTRODUCTION

Proximal humerus fractures, comprising about 6% of adult fractures, show an increased incidence with age and impact women twice as often as men. In Sweden, a registry-based study between 2001 and 2012 revealed a 44% rise in annual incidence. These injuries, commonly resulting from falls at standing height, exhibit seasonal fluctuations, occurring more frequently in winter. Most are closed injuries.^{1,2}

The Neer classification, defining four anatomical parts of the proximal humerus, utilizes criteria of displacement or angulation exceeding 1 cm or 45°, determining the classification of one-, two-, three-, or four-part fractures. This system, evolving to encompass additional features, accounts for the fracture's anatomical components, aiding pathoanatomy understanding. Another classification, AO/OTA, simplifies coding by integrating Neer's criteria, identifying three main fracture types with further sub-classifications. Additionally, the Hertel classification considers fracture morphology and related characteristics to predict humeral head ischaemia.^{3,4} There's debate over what defines a minimally displaced shoulder fracture, with varying estimates from studies. Despite classification variations, the consequences of these fractures are substantial, often necessitating inpatient rehabilitation and social care. Long-term outcomes post-treatment are frequently unsatisfactory, with persistent pain and reduced shoulder function reported even after two years.¹

Treatment goals aim to alleviate pain and achieve optimal function, although most patients don't fully regain pre-injury shoulder function. Notably, non-operative treatment of displaced fractures in adults may result in inevitable malunion, yet satisfactory patient-reported outcomes are achievable without anatomical restoration or joint replacement.⁵ The evidence base for managing these fractures has historically been weak, with a scarcity of high-quality studies. Consequently, approaches to treatment vary widely, with surgical modalities receiving more attention despite equivocal findings on their superiority. Emerging options like reverse total shoulder arthroplasty lack robust supporting evidence despite gaining popularity in recent years.⁶

Proximal humerus fractures present a significant challenge in orthopedic care, accounting for a notable portion of adult fractures. The management of these fractures encompasses a spectrum of interventions, from non-operative measures to various surgical techniques. The aim of this systematic review is to critically evaluate the existing literature on the management strategies employed for proximal humerus fractures in adults. By synthesizing available evidence, this review seeks to elucidate the comparative effectiveness, complications, and patient-reported outcomes associated with different treatment modalities.

METHODS

Protocol

The researchers in this study followed the 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines to ensure that their work met the required standards. This was done to ensure the precision and reliability of the conclusions derived from the research.

Criteria for Eligibility

To be considered in this study, eligible articles had to adhere to specific criteria. They were required to be English-language research papers concentrating on the management of proximal humerus fractures in adults. These studies needed to satisfy the following conditions: publication dates post-2018 falling within the designated timeframe for this systematic review. Articles falling under categories such as editorials, lacking a DOI, previously published review articles, or duplicating content from prior journal publications were excluded from the evaluation process.

Search Strategy

We conducted a comprehensive literature search using PubMed and Science Direct journal database, focusing on studies published from 2018 to 2024. The search terms employed were as follows ("manage"[All Fields] OR "managed"[All Fields] OR "management s"[All Fields] OR "managements"[All Fields] OR "manager"[All Fields] OR "manager s"[All Fields] OR "managers"[All Fields] OR "manages"[All Fields] OR "managing"[All Fields] OR "managment"[All Fields] OR "organization and administration"[MeSH Terms] OR ("organization"[All Fields] AND "administration"[All Fields]) OR "organization and administration"[All Fields] OR "management"[All Fields] OR "disease management"[MeSH Terms] OR ("disease"[All Fields] AND "management"[All Fields]) OR "disease management"[All Fields]) AND ("proximal"[All Fields] OR "proximalization"[All Fields] OR "proximalize"[All Fields] OR "proximalized"[All Fields] OR "proximalizes"[All Fields] OR "proximalizing"[All Fields] OR "proximally"[All Fields] OR "proximals"[All Fields]) AND ("humeral fractures"[MeSH Terms] OR ("humeral"[All Fields] AND "fractures"[All Fields]) OR "humeral fractures"[All Fields] OR ("humerus"[All Fields] AND "fractures"[All Fields]) OR "humerus fractures"[All Fields]) AND ("adult"[MeSH Terms] OR "adult"[All Fields] OR "adults"[All Fields] OR "adult s"[All Fields])

Inclusion and exclusion criteria

The studies included had specific criteria: (1) they needed to be original research exploring the management of proximal humerus fractures in adults; (2) they could be Randomized Controlled Trials (RCTs) or observational studies (cohort or case-control studies); (3) relevant data had to be accessible. On the other hand, certain studies were excluded if they: (1)

were ongoing or lacked available data; (2) were duplicates, in which case the most recent article was selected; (3) were not in English.

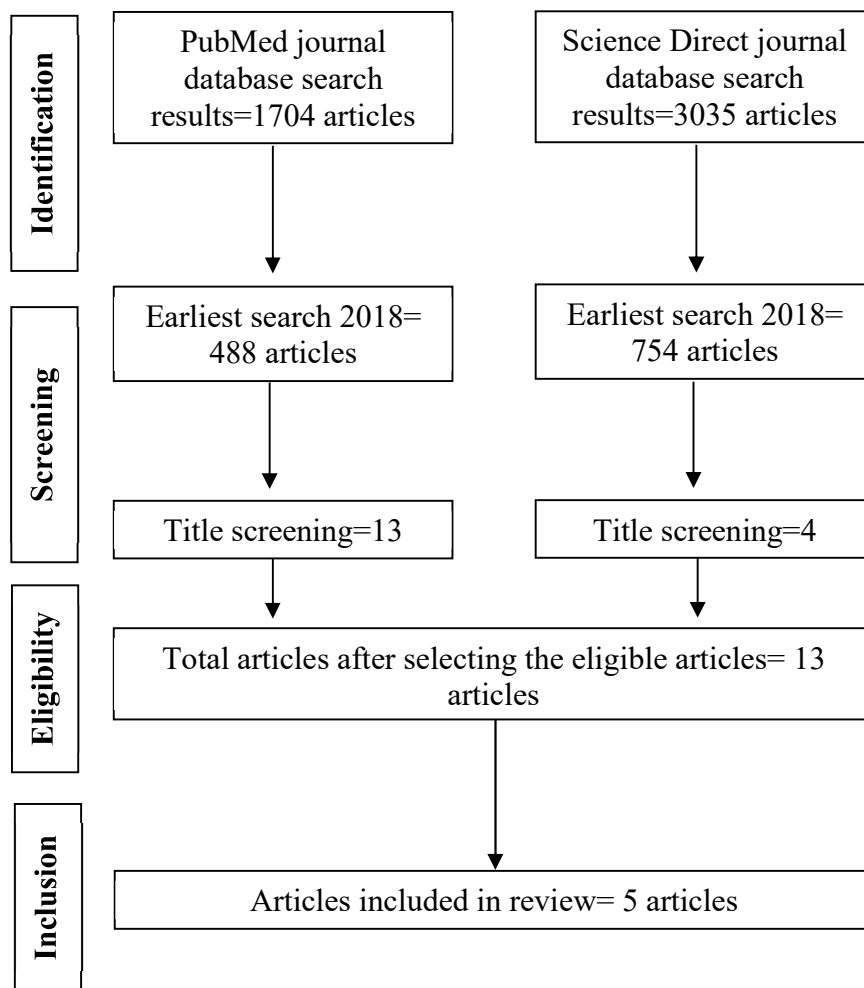


Figure 1. Article search flowchart

Data Retrieval

The authors conducted a thorough examination of relevant studies, specifically selecting those that met precise inclusion criteria. They focused on original, unpublished papers in English to ensure a refined and high-quality selection. The analysis covered essential information, such as study particulars, authors, publication dates, locations, and research methodologies, aligning with the study's objectives.

Author	Origin	Method	Sample Size	Result
Yahuaca et al., 2020. ⁷	USA	Retrospective review analytical study	In a total of 425 shoulders that met the inclusion criteria.	Average age for treatment groups was 65 13 years (range: 18-93 years). Fractures were classified as 2- (11%), 3- (41%), or 4-part (48%). Age, ASA, and fracture classification were associated with selected surgical management (P <.0001, ¼.001, <.0001, respectively). Outcomes showed a significant improvement in forward flexion from 3 months to 6 months in all groups (P <.0001). No difference in final motion was seen between groups. Radiographic union was higher in ORIF (89%), and similar between HA (79%) and RSA (77%, P ¼.005). Rate of reoperation was RSA 6.6%, ORIF 17.5%, and hemiarthroplasty 15.7% (P ¼.029). Postoperatively, 23% patients had at least 1 fall, of which 73% resulted in fractures.
Howard et al., 2018. ⁸	Ottawa, Canada	Prospective, randomized control led	One-hundred and sixty patients > age 60 with acute	Primary outcome measures encompass validated scoring systems like the Constant Score, emphasizing range of motion and strength, alongside the American Shoulder and Elbow Surgeon’s (ASES) Score, combining patient self-assessment and clinical evaluation. Additionally, the EuroQol EQ-5D-5 L Health Questionnaire and the Short Form PROMIS Upper Extremity Score measure health-related

		trial protocol	3- or 4-part proximal humerus fractures	quality of life and upper limb function, respectively. The IPAQ for the Elderly surveys physical activities in the elderly. Secondary measures involve radiographic assessments for fracture classification, alignment, and complications, including non-union and osteoarthritis detection. Compliance and follow-up strategies are employed, and statistical analyses, including ANOVA and regression, will explore outcomes, complications, and associations between variables, with specific focus on fracture types and prognostic factors.
Miquel et al., 2021. ⁹	Spain	A retrospective study.	Sixty-four patients were retrospectively classified by age, sex, and the Neer fracture classification	Forty-six patients with a mean follow-up of 58 (24–132) and a mean age of 58 years old were analyzed. Patients with 2pGT (n = 10) fractures had a CMS of 76 points (59–89); patients with 3-part fractures (n = 22) had a score of 67 points (13–91); and those with 4-part fractures (n = 14) had a score of 64 (24–76) points. The overall complication rate was 6 out of 46, and 4 patients required reintervention for different reasons. Patients presenting with 3-part varus fractures had significantly lower functional outcomes scores (p = 0.007). Humeral head osteonecrosis was present in 9 patients and significantly affected the functional outcomes (p < 0.05). However, only three out of nine patients with osteonecrosis required subsequent surgery at the indicated follow-up
Liu et al., 2023. ¹⁰	China	Retrospective, comparative cohort study	52 patients with proximal humeral fractures who required hospitalization.	Group 1 had a shorter mean operative time than group 2 (2.25 ± 0.30 h vs 2.76 ± 0.44 h; P = 0.000). Group 1 had a lower shoulder wound pain score on the first day after surgery than group 2 (7.91 ± 1.15 points vs 8.56 ± 1.00 points; P = 0.044). Group 1 had a shorter fracture healing time than group 2 (2.68 ± 0.48 mo vs 3.64 ± 0.64 mo; P = 0.000). Group 1 had higher Constant-Murley scores of the shoulder joint at 3, 6, and 12 mo after surgery than group 2 (76.64 ± 4.02 points vs 72.72 ± 3.02 points, 86.36 ± 3.53 points vs 82.96 ± 3.40 points, and 87.95 ± 2.77 points vs 84.68 ± 2.63 points, respectively; P = 0.000, 0.002, and 0.000, respectively). Group 1 had higher Mallet scores of the shoulder joint at 3, 6, and 12 mo after surgery than group 2 (10.32 ± 0.57 points vs 9.96 ± 0.54 points, 13.36 ± 1.00 points vs 12.60 ± 0.87 points, and 13.91 ± 0.75 points vs 13.36 ± 0.70 points, respectively; P = 0.032, 0.007, and 0.013, respectively).
Klug, et al., 2019. ¹¹	Germany.	Retrospective study	642,556 cases of proximal humerus fracture.	There were 642,556 cases of PHF. During the study period, incidence changed substantially from 65.2 to 74.2 per 100,000 inhabitants with a significant rise in elderly (> 70 years) patients (P < 0.001). The number of surgical procedures increased by 39%, with locking plate fixation being the most common procedure (48.3%), followed by intramedullary nailing (IMN) (20.0%), hemiarthroplasty (HA) (7.5%), K-wire fixation (6.4%), and reverse shoulder arthroplasty (RSA) (5.6%). The utilization rate increased for locking plates, K-wires, and RSA and decreased for HA and IMN. Particularly, the utilization of RSA exhibited a > eightfold increase. Significant linear correlation of procedure and time were found for all surgical treatments.

RESULT

Our search produced 13 results. After looking at the titles and summaries, we found several papers that fit our criteria. At first, we excluded few articles because they were written in review and case report style. But after reading the full papers carefully, we included five papers in our final analysis. These papers included prospective, retrospective studies, and prospective randomized control trial study.

In a cohort of 425 shoulders meeting inclusion criteria, surgical distribution comprised 49.6% ORIF, 25.4% hemiarthroplasty (HA), and 24.9% reverse total shoulder arthroplasty (RSA). Predominantly female patients accounted for 76.7% of cases. Each surgical approach showed a high proportion of female representation: 76.8% for ORIF, 71.3% for HA, and 82.1% for RSA. However, no significant sex-based differences were noted in surgical type (P = .176).⁷

The average age at surgery was 65 ± 13 years, displaying significant age-related patterns across surgeries: ORIF (62 ± 13 years), HA (65 ± 12 years), and RSA (73 ± 9 years) (P < .0001). ASA scores correlated significantly with surgical approach (P = .001), with RSA patients more likely to have higher ASA scores (79%) compared to HA (66%) and ORIF (55%) (P = .001). Surgical selection aligned strongly with fracture characteristics, where 2- and 3-part proximal humerus fractures (PHFs) leaned towards ORIF (93% and 64%, respectively), while 4-part PHFs were more prone to RSA (39%) (P < .0001). All groups showed significant improvement in forward flexion (FF) from 3 to 6 months (HA: P < .0001; ORIF: P

< .0001; RSA: $P = .001$) and 6 months to the final visit ($P < .01$). At 6 months, FF was significantly better in ORIF and RSA compared to HA ($P < .0001$ and $P = .005$, respectively), with differences maintained at the final follow-up ($P = .002$). Radiographic outcomes revealed malunion, nonunion, or hardware complications in 25% of ORIF, 30% of HA, and 15% of RSA cases. Tuberosity or fracture union was notably higher in the ORIF group than HA and RSA ($P = .002$). Reoperation rates differed significantly: RSA 6.6%, HA 15.7%, and ORIF 17.5% ($P = .029$). Subsequent falls postoperatively affected 23% of patients, with distal radius fractures being most common (28%). Females experienced more falls (84%) without statistical significance ($P = .063$), and ASA scores did not significantly associate with fall occurrence ($P = .747$).⁷

In randomized controlled trial conducted by Howard et al (2018) patients, primarily comprising males and females over 60 years old with acute, displaced proximal humerus fractures (Neer categories of 3- or 4-part), will be screened in the emergency department of a university-affiliated hospital and subsequently enrolled in the fracture clinic. The diagnostic criteria involve radiographs comprising a true AP (neutral rotation), a lateral Y-view, and an axillary view to confirm the fracture type. Orthopedic Surgeons will independently assess the fractures, and any classification disagreement will be resolved by a consensus among three surgeons. Enrolled patients consenting to participate will undergo baseline functional assessments, including scoring systems such as Constant, ASES, EQ-5D-5 L, PROMIS, and IPAQ. Those randomized into the surgical arm will receive surgery within seven days.⁸

The study aims to include 160 patients, considering a minimum clinically important difference in the Constant score and accounting for possible crossovers and loss-to-follow-up. Randomization into treatment arms, non-operative or ORIF, will occur within seven days of injury onset or immediately in case of patient inability to return home. Blinding the surgeon or patient to treatment allocation won't be feasible due to the trial nature. However, the research coordinator will conduct blinded follow-up assessments to minimize bias. Trained musculoskeletal radiologists will perform radiological assessments.⁸

For the non-operative treatment arm, patients will receive sling immobilization for six weeks, gradually transitioning to active mobilization after that period. In the operative treatment arm, surgeons will adhere to a standardized protocol using specific fixation hardware. Postoperative rehabilitation protocols for both arms will align with the non-operative approach. Outcome measures include functional assessments at various intervals and recording complications and adverse events immediately post-surgery and during follow-up visits. Standardized case-report forms will document complications, facilitating clinical evaluation during follow-ups for issues like infection, nerve injury, hematoma formation, or hospital re-admission.⁸

Sixty-four patients were initially eligible for the osteosuture technique within three weeks of their injury. However, three patients didn't complete a minimum 24-month follow-up, and another 15 were lost to follow-up. Consequently, 46 patients successfully completed a minimum 24-month follow-up and were included in the analysis. Their mean age was 58 years (ranging from 28 to 86), consisting of 30 females and 16 males. The mean follow-up duration was 58 months (ranging from 24 to 132), with surgeries performed within 11 days (ranging from 1 to 22) post-injury.⁹

Functional outcomes measured using the Constant-Murley score, categorized based on the Neer classification. For 3-part fractures, the average Constant-Murley score stood at 67.15 points. Notably, 3-part valgus impacted fractures scored an average of 72.26 points, significantly higher than 3-part varus or neutral fractures, which obtained notably lower outcomes at an average of 42.52 points (ranging from 13 to 72.7, $p = 0.0013$). Meanwhile, 4-part fractures averaged 51.75 points at follow-up. Regarding radiological outcomes, nine patients exhibited humeral head avascular necrosis during the follow-up, while seven showed signs of osteoarthritis based on X-ray evaluations.⁹

Six patients encountered postoperative complications. Transient axillary nerve injuries were observed in three patients, resolving with conservative treatment, while another experienced transient ulnar nerve neuropraxia, also healing non-operatively. Two patients faced postoperative shoulder stiffness, one of whom needed arthroscopic capsular release for a 4-part valgus fracture, while the other recovered with conservative treatment. Tragically, one patient passed away due to postoperative bronchoaspiration.⁹

Four patients required reinterventions, occurring at a mean time of 23.5 months post-index surgery. Interventions included arthroscopic capsular release for postoperative shoulder stiffness and salvage procedures for humeral head avascular necrosis, primarily hemiarthroplasty or reverse shoulder arthroplasty. The presence of humeral head avascular necrosis notably affected functional outcomes. Patients with HHAVN had an average CMS of 35.9 points, significantly lower than those with an intact humeral head, averaging 70.7 points ($p < 0.01$). Despite this, not all patients with HHAVN required reintervention; only three out of nine underwent salvage procedures. Remarkably, six patients declined further surgery even when it was offered. The mean Constant-Murley score for patients declining surgery due to HHAVN was 41.72 (ranging from 24 to 54.30). No patients needed a salvage procedure for osteoarthritis during the follow-up period.⁹

This research involved 47 patients who completed the follow-up entirely. There was no significant difference noted in the mean volume of intraoperative blood loss from the shoulder wound between the studied groups. In group 1, the average volume of intraoperative blood loss from the leg wound measured 37.27 mL (SD, ± 13.86 mL), and the mean fibula length

was 7.64 cm (SD, \pm 1.53 cm). Group 1 showcased a shorter mean duration of the surgical procedure compared to group 2. Furthermore, on the first day following surgery, group 1 exhibited lower shoulder wound pain scores than group 2. The leg wound pain score on the first postoperative day was 5.68 points (SD, \pm 0.78 points). Group 1 also displayed a faster healing time for fractures compared to group 2.¹⁰

Regarding the functional evaluation, Group 1 indicated higher Constant-Murley scores for the shoulder joint at 3, 6, and 12 months post-surgery in comparison to Group 2. Both groups showed a Holden walking function of grade V preoperatively and postoperatively. However, Group 1 demonstrated superior Mallet scores for the shoulder joint at 3, 6, and 12 months post-surgery compared to Group 2. During the surgery, there was no disparity in the humeral neck-shaft angles between groups 1 and 2. However, at the 12-month mark after surgery, Group 1 displayed larger humeral neck-shaft angles compared to Group 2. Notably, both the shoulder and calf wounds healed entirely without any incidence of infection or necrosis.¹⁰

Between 2007 and 2016, Germany reported a total of 642,556 proximal humerus fractures (PHFs), showcasing a steady annual increase from 53,553 in 2007 to 61,231 in 2016, indicating a 14.3% rise. Adjusted for Germany's population growth, the annual incidence surged from 65.2 to 74.2 per 100,000 individuals ($P < 0.001$), displaying significant gender-based differences: 38 per 100,000 person-years for men and 108 per 100,000 person-years for women. Notably, about 70.5% of PHFs occurred among elderly patients, with peak incidences in females between 75 and 85 years and in males between 65 and 75 years. Over the study duration, there was a noticeable shift towards PHF incidence among elderly patients, marking an increase in age-adjusted incidence from 280.0 to 351.4 per 100,000 ($P < 0.01$).¹¹

Surgical interventions reflected this rise in PHFs, showing a 38.8% increase over the study period, with around 68.9% of procedures performed on elderly patients. Open reduction internal fixation (ORIF) was the primary intervention in 72.1% of cases, with a steady increase in shoulder arthroplasty compared to consistent ORIF numbers. Locking plate fixation constituted about 48.3% of surgical interventions, followed by intramedullary nails (IMN) at 20.0%, hemiarthroplasty (HA) at 7.5%, ORIF using K-wires at 6.4%, and reverse shoulder arthroplasty (RSA) at 5.6%. The usage of locking plates increased significantly by 46.3% until 2010 and stabilized thereafter at an annual utilization rate of 49.3% over the last five years. Conversely, non-locking plates and intramedullary nails witnessed substantial decreases, while ORIF with K-wires notably surged, particularly among the elderly.¹¹

Across the decade, the number of shoulder prostheses implanted annually nearly doubled. Although HA was more prevalent (57.1%) than RSA (42.9%) overall, RSA escalated from 586 in 2007 to 5977 in 2016. This growth in RSA was prominent in elderly patients, surging by 1218.2%, while its use increased significantly even in younger patients ($P < 0.001$). In contrast, HA decreased by 52.5%, notably declining in patients over 70 years and even among younger patients. By 2014, RSA had surpassed HA, constituting almost 77.0% of all PHF prostheses in 2016. Procedural differences were noticed concerning age and gender. Men had higher age-standardized ratios for the five most common procedures under 50 years of age. Notably, distinct gender discrepancies were evident in patients over 80 years treated with RSA, with significantly higher rates among women than men.¹¹

Moreover, significant linear correlations over the decade were found for RSA, HA, locking plates, IMN, and K-wires concerning treatment modality and time. A subgroup analysis based on ICD-10 classification revealed varying treatment approaches for different PHF types, showing specific utilization rates for interventions across different fracture types.¹¹

DISCUSSION

Yahuaca et al.'s study observed age influencing the choice of surgical approach for proximal humerus fractures (PHFs). Patients over 65 favored open reduction internal fixation (ORIF), while those older than 65 leaned toward arthroplasty. Gupta et al.'s review similarly noted older patients opting for reverse shoulder arthroplasty (RSA) due to studies suggesting better outcomes with arthroplasty over ORIF in this group. Our study confirmed higher reoperation rates and nonunion in those over 65 undergoing ORIF, contrasting with those 65 and younger.⁷

Interestingly, higher ASA scores correlated with a higher likelihood of arthroplasty in our study but didn't predict functional outcomes or complications. This contrasts with previous findings correlating higher ASA scores with surgical complications in arthroplasty patients. This study found varied surgical approaches based on Neer's fracture classification, with ORIF common in two- and three-part fractures and RSA in four-part fractures. Determining the best treatment for three-part fractures remains challenging due to multiple factors, including patient variables and bone quality.⁷

Literature presents conflicting results in comparing surgical options for PHFs. Gupta's review favored ORIF for motion, while other studies reported conflicting outcomes with hemiarthroplasty (HA) or ORIF. RSA showed improved motion compared to HA, aligning with Chalmers' findings, which highlighted better early motion and cost-effectiveness. Reoperation rates significantly influenced PHF management. Gupta et al. reported higher rates with ORIF and RSA. Similarly, our study found significantly higher rates for HA than previously reported.^{7,12}

Furthermore, the study emphasized postoperative falls (23%) and subsequent fractures (19%), highlighting the burden on patients. Counseling on fall prevention strategies and home-based exercises could reduce these risks. A comprehensive approach covering fall prevention, bone density, and comorbidity management is crucial for PHF recovery.

The management of proximal humeral fractures remains a topic of debate. Previous randomized studies haven't shown discernible differences in patient outcomes between non-operative treatment and open reduction internal fixation (ORIF).^{13,14} However, two of these studies had relatively small sample sizes. Surgical complications and higher mortality rates are more frequent among the elderly¹⁵, thus avoiding unnecessary surgery could reduce patient morbidity and healthcare costs.

The PROFHER trial, the largest multi-centered randomized controlled trial comparing operative versus nonoperative treatment for proximal humerus fractures, didn't reveal significant differences in functional outcomes between the treatment groups when using the Oxford and SF-12 functional outcome scoring systems. However, this trial had certain methodological limitations that the current study aims to address. The PROFHER trial encompassed patients aged over 16 years, but the functional demands in younger patients differ significantly from those of older patients. The present trial, therefore, limits the study to patients over 60 years old, offering more focused insights. Other limitations of the PROFHER study, such as lack of blinding, varied rehabilitation programs, and low enrollment in certain centers, have been addressed in the current trial. This includes blinding of research personnel, standardized rehabilitation protocols, and enrollment at a large, high-volume, tertiary care center.⁸

Moreover, study by Howard et al utilizes pre-operative CT scans to analyze fracture displacement/angulation and includes the IPAQ score, tailored for the elderly population, to assess functional demands and their impact on performance in other functional assessment tools. This data will present level 1 evidence that could significantly influence the management of proximal humerus fractures in the elderly, aiding surgeons in recommending the most effective treatment while considering imaging characteristics.⁸

The data presented in this paper advocate for a hardware-free approach to restore bone fragment anatomy in displaced proximal humeral fractures treated with open reduction and internal fixation. Notably, both 2-part GT fractures and 3-part valgus fractures exhibited favorable Constant-Murley scores during follow-up, with no severe technique-related complications observed. However, complications were noted in 6 out of 46 patients. Interestingly, the presence of humeral head avascular necrosis didn't invariably result in reinterventions, resulting in a low rate of additional surgeries associated with this technique.⁹

Functional outcomes in our series align with those reported in the literature when rigid hardware fixation is employed for proximal humeral fractures.¹⁶ Patients with 2-part fractures demonstrated good results based on the CMS without any complications or need for reinterventions. However, 3-part varus fractures showcased poorer functional outcomes compared to 3-part valgus or neutral fractures. This aligns with findings suggesting that preoperative varus displacement could impact postoperative outcomes and elevate the risk of failure with rigid hardware fixation techniques.⁹

Our study indicates fair outcomes for patients with 4-part fractures based on the CMS, although a subset of these patients required subsequent surgery. However, we couldn't replicate results seen in other studies using similar techniques for 4-part valgus fractures, leading us to recommend the use of the osteosuture technique specifically for 4-part valgus impacted fractures when open reduction and internal fixation is preferred.⁹

Studies questioning the benefits of open reduction and internal fixation using locking plates have prompted discussions around implant-related complications, which have varied reports ranging from 0 to 30%. Authors have suggested early hardware removal to avert these complications, indicating a higher likelihood of reoperations with the use of locking plates for proximal humeral fractures. Concerning nails, complications related to rotator cuff issues have been reported between 24 to 73%, with revision rates ranging from 10 to 42%, primarily depending on the nail design. Regular follow-ups are recommended to identify potential screw perforation and plan for timely screw removal. The presence of humeral head avascular necrosis was observed in some patients, impacting functional outcomes as assessed by the Constant-Murley score. However, despite this complication, the hardware-free technique didn't necessarily lead to further surgeries in most cases, with only a fraction requiring additional intervention.⁹

This retrospective comparative study highlighted improved shoulder function scores in group 1 patients with complete follow-up data. Using locking plates with a fibular autograft for proximal humeral comminuted fractures potentially reduced operative time by aiding fracture reduction. Although the fibular autograft added surgical time, it shortened the overall operative duration, possibly contributing to lower wound pain scores in group 1. Enhanced postoperative scores might be attributed to stronger fixation achievable with fibular bone grafting, aiding rehabilitation and maintaining post-surgery fracture reduction. Additionally, it minimized postoperative reduction loss.¹⁰

The autogenous fibular bone grafting method eased surgical difficulty, augmented medial support, fortified fixation strength, allowed fibula insertion in the medullary cavity, simplified surgery, and facilitated fracture healing and functional recovery, according to previous studies. Indications for its use include elderly patients with severe fractures lacking medial

support and Neer type III or IV fractures. When institutional resources for fibular allografts or shoulder joint replacements are limited, the autogenous fibular segment presents a viable alternative. Although this technique involves additional incisions and may cause initial pain, it offers advantages such as enhanced fixation, reduced surgical complexity, and earlier functional ability, promoting improved shoulder function recovery. This method, albeit slightly more expensive than traditional techniques, might offer beneficial implications, especially in regions where fibular allograft materials are scarce and expensive.¹⁰

In the past decade, the incidence of proximal humerus fractures (PHFs) among the elderly has increased by 14.3%. Women, typically older than men, are more affected. Surgical interventions for PHFs have surged by 38.8%, aligning with trends in recent literature. Although non-operative approaches show promise, the trend toward more aggressive treatments persists, likely due to advancements in techniques and worsening PHF severity in aging bones.¹¹

Locking plate fixation, most commonly used, saw a rise in use until 2010, followed by a slight decline. This decrease aligns with increased utilization in patients aged 60 to 70, possibly due to better bone quality in younger patients favoring Open Reduction Internal Fixation (ORIF). However, debates persist over the technology's benefits and complications. ORIF shows higher functional scores but also elevated complication rates, especially in the elderly due to concerns about soft-tissue damage and blood supply disruption.¹¹

Minimally invasive techniques and intramedullary nails (IMN) have gained traction for PHFs owing to biomechanical advantages. Yet, controversies exist over their superiority compared to locking plates. IMN usage has slightly decreased, potentially due to aging populations and an increase in complex fractures, hindering indirect fracture reduction. Shoulder arthroplasties, particularly Reverse Shoulder Arthroplasty (RSA), have seen a significant increase, suggesting RSA as a reliable option for complex PHFs in the elderly. This contrasts with declining Hemiarthroplasty (HA) use, associated with unpredictable motion and higher complication rates. While long-term studies are scarce, recent trends point toward a growing preference for RSA in managing PHFs. These shifts in treatment approaches highlight the evolving landscape and growing considerations in managing PHFs, especially among aging populations.¹¹

CONCLUSION

This comprehensive study compared Open Reduction Internal Fixation (ORIF), Hemiarthroplasty (HA), and Reverse Shoulder Arthroplasty (RSA) while evaluating comorbidities, fracture complexity, postoperative falls, and subsequent fractures in Proximal Humerus Fracture (PHF) patients. The findings supported that ORIF tended to be performed in younger patients with less complex fractures, while RSA was preferred in older patients with higher ASA scores and more complex fractures, confirming our primary hypothesis. ORIF showed superior final range of motion compared to HA, and although it had a higher fracture union rate, this was mainly attributed to the predominance of 2-part PHFs treated with ORIF. Notably, ORIF and HA had higher reoperation rates than RSA, crucial information when discussing surgical options with patients.

An important revelation was the postoperative fractures among surgically managed PHF patients. This study confirmed that a significant proportion experienced subsequent falls, leading to fractures, which raises concerns for public health. Proper counseling is vital post-PHF treatment to prevent future falls and fractures that can hinder functional status and quality of life. The controversies surrounding the optimal management of PHFs persist, with prior randomized studies failing to exhibit significant differences in patient-centered outcomes between non-operative and operative treatments. Yet, surgical complications and mortality, particularly in the elderly, underline the need to minimize unnecessary surgeries, reducing patient morbidity and healthcare costs.

Given the increase in PHF incidence and surgical procedures, the shift in treatment approaches, particularly the rise in RSA and decline in HA, especially among elderly patients, aligns with current scientific evidence. The decrease in Intramedullary Nail (IMN) usage suggests limitations in treating complex fractures within an aging population, while the increased use of minimally invasive procedures, notably Kirschner wire (K-wire) fixation, indicates advancements in elderly care. To address the lack of standardized treatment guidelines and cope with the rising PHF incidence due to an aging population, comprehensive value-based studies and unified registry databases are crucial. These would aid in comparing treatment modalities and establishing evidence-based protocols for effective PHF management.

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