Proximal Humerus Fractures: Reverse total shoulder arthroplasty versus Augmented Plate with Allograft. A comparative analysis

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DOI: 10.58542/jbota.v63i1.209

Abstract- Background. Proximal humerus fractures (PHFs) represent approximately 5% of all fractures, occurring predominantly in elderly patients with osteoporosis. Functional limitations and high complication rates are common results after PHFs treatment . The aim of this study was to compare the functional outcomes and complications between reverse total shoulder arthroplasty (rTSA) and locking plate (LP) fixation augmented with intramedullary fibular allograft (IFA) in patients older than 65 years with four-part PHFs.

Methods. A retrospective comparative analysis was performed including 72 patients: 37 treated with rTSA and 35 with LP fixation augmented with IFA. Mean follow-up was 30 months for the rTSA and 31 months for the ORIF with LP and IFA group. Functional outcomes were assessed using the Constant-Murley score (CMS) (absolute and relative) and the Disabilities of the Arm, Shoulder and Hand (DASH) score. Complication and revision rates were recorded.

Results. The rTSA group demonstrated higher CMS (absolute 74.3 vs 60.3; relative 92.3 vs 79.5), while DASH scores were comparable (14.5 vs 15.8). Although clinically relevant the difference was not of statistical significance. In the LP fixation, avascular necrosis of the humeral head occurred in 34.3% and greater tuberosity necrosis in 17.1%. The rTSA group demonstrated fewer complications, while reoperation rates were similar between groups (8.1% vs 8.6%).

Conclusion. RTSA demonstrated a trend toward better functional outcomes and lower complications compared with LP with IFA. The latter remains a viable reconstructive option providing medial calcar support when joint preservation is preferred. More patients with randomisation are needed to further confirm these results.

Keywords— CPAK classification, kinematic alignment, total knee arthroplasty, phenotyping, arithmetic HKA, joint line obliquity.

1. INTRODUCTION

Proximal humerus fractures account for approximately 5% of all fractures and occur predominantly in elderly patients with osteoporosis. The treatment outcomes frequently result in functional impairment and reduced quality of life, especially for four-part fractures. The best treatment method for this type of PHFs still remains controversial.

Conservative treatment for unstable PHFs is associated with poor functional recovery, while most common surgical approaches are locking plate (LP) fixation and reverse total shoulder arthroplasty (rTSA)[(1)]. Augmentation with fibular strut allograft has been proposed to provide medial column support, while reducing varus collapse and enhancing construct stability in osteoporotic bone[(2)].

Conversely, rTSA is increasingly used in elderly patients with complex PHFs because it is less dependent on tuberosity healing and rotator cuff integrity, and has been associated with favorable functional outcomes and lower revision rates compared with fixation techniques[(3,4)]. Currently, direct comparisons between rTSA and LP fixation augmented with intramedullary fibular allograft (IFA) are limited. Therefore, the aim of this study was to compare functional outcomes and complication rates in patients older than 65 years with four-part PHFs treated with rTSA and LP fixation augmented with IFA.

2. Materials and methods

A. Study Design and Setting

This study was designed as a retrospective comparative cohort analysis evaluating functional and radiological outcomes after surgical treatment of four-part PHFs in elderly patients. The investigation compared rTSA with LP fixation augmented by IFA. The study was conducted at a Level 1 trauma center and included consecutive patients treated within the defined study period.

B. Patient Selection

Medical records and surgical databases were screened to identify patients older than 65 years who underwent surgical treatment for PHFs. Inclusion criteria were:

- age greater than 65 years at the time of injury
- four-part proximal humerus fracture according to the Neer classification
- surgical treatment with either r TSA or LP with IFA
- minimum follow-up of 12 months

Patients with pathological fractures, previous surgery on the affected shoulder, or follow-up less than 12 months data were excluded.

A total of 72 patients met the inclusion criteria. Thirty-seven patients were treated with rTSA, and thirty-five underwent ORIF with LP and IFA augmentation

C. Demographic data

Baseline demographic characteristics were comparable between groups. The mean age was 73 years in the rTSA cohort and 71 years in the LP fixation cohort. Both groups consisted predominantly of female patients, reflecting the epidemiology of osteoporotic proximal humerus fractures.

Bone quality was indirectly assessed using the Deltoid Tuberosity Index (DTI) on preoperative radiographs. The mean DTI was 1.33 in the rTSA group and 1.37 in the ORIF with LP and IFA, indicating similar osteoporotic bone characteristics between cohorts.

D. Surgical Technique

1) Reverse Total Shoulder Arthroplasty

rTSA was performed using an onlay humeral design through a standard deltopectoral approach. Humeral fixation was achieved with either cemented or uncemented stems depending on intraoperative bone quality. Restoration of appropriate humeral length and soft-tissue tension was pursued in all cases.

The subscapularis tendon was routinely repaired in every patient. Tuberosity repair was routinely attempted using nonabsorbable sutures to optimize postoperative external rotation and functional recovery. The mean follow-up duration for the arthroplasty group was 30 months.

2) ORIF with LP and IFA

Open reduction and internal fixation was performed using a proximal humerus internal locking system (PHILOS plate). An IFA was used to augment fixation and restore medial column support in osteoporotic bone. In the majority of cases, the graft was positioned centrally within the intramedullary canal. Reduction aimed to restore humeral head alignment, medial calcar support, and anatomical tuberosity position.

Both frozen and lyophilized fibular grafts were utilized depending on availability. Surgical exposure was achieved either through a deltopectoral or McKenzey approach and MIPO technique. The mean follow-up duration in this group was 31 months.

E. Postoperative Management and Rehabilitation

Postoperative rehabilitation followed standardized institutional protocols and differed slightly between treatment groups.

After rTSA the operated shoulder was immobilized for a minimum of three weeks using a Dessault-type orthosis. Following this period, assisted and active shoulder motion was initiated within the pain-free range, including elevation beyond 90 degrees when tolerated. Rotational movements were introduced cautiously to protect tuberosity healing and soft-tissue repair.

In the LP and IFA, postoperative immobilization was maintained for four weeks before gradual initiation of mobilization according to radiographic and clinical progression.

F. Outcome Measures

Clinical outcomes were assessed at final follow-up using the Constant–Murley score (CMS), reported as both absolute and age- and sex-adjusted relative values. Functional disability was evaluated using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.

Complications were recorded, including:

- avascular necrosis (AVN) of the humeral head or greater tuberosity AVN (GTAVN)
- infection
- instability or dislocation
- implant-related complications
- need for reoperation

Radiological evaluation included assessment of implant position, fracture healing, and signs of osteonecrosis or mechanical failure.



Figure 1. A 68-year-old female patient with a four-part proximal humerus fracture. (A) Preoperative anteroposterior radiograph demonstrating a displaced four-part fracture of the proximal humerus. (B) Immediate postoperative radiograph following ORIF using a LP combined with IFA. (C) Three-year follow-up radiograph showing development of AVN of the humeral head with secondary collapse. (D) Postoperative radiograph after conversion to rTSA.

3. RESULTS

At final follow-up, patients treated with rTSA demonstrated higher functional outcomes compared with those treated with LP and IFA The mean absolute Constant score in the arthroplasty group was 74.3, compared to 60.3 in the LP and IFA group ($p = 0.102$). Similarly, the relative CMS was higher following arthroplasty (92.3 versus 79.5), with the difference approaching statistical significance ($p = 0.058$). The DASH score showed comparable functional disability between the two groups, with mean values of 14.5 in the arthroplasty group and 15.8 in the osteosynthesis group ($p = 0.438$). Overall, all functional parameters demonstrated a consistent trend favoring rTSA.

The complication profile differed between the two treatment methods. In the LP with IFA, AVN of the humeral head was observed in 34.3% of patients, while GTAVN occurred in 17.1%. Three patients (8.6%) required reoperation, primarily for implant removal or screw exchange. No deep infections were recorded in this cohort. Scapular notching was not detected on at the final radiological follow-up in the rTSA group

In the rTSA group, two patients (5.4%) experienced postoperative instability associated with infection, and one additional patient (2.7%) developed infection without dislocation. Reoperation was required in three cases (8.1%), and one instance of implant disassembly (2.7%) was documented. Despite the different complication patterns, the overall reoperation rate was comparable between the two study groups.

Taken together, the results demonstrate higher functional scores and fewer complications related to humeral head viability in the arthroplasty group, although none of the functional differences were of statistical significance.

Variable	rTSA Group	LP + IFA Group	p value
Constant–Murley Score (absolute)	74.3	60.3	0.102
Constant–Murley Score (relative)	92.3	79.5	0.058
DASH Score	14.5	15.8	0.438

Table 1. Functional Outcome Comparison at Final Follow-up

4. DISCUSSION

Management of complex PHFs in elderly patients remains controversial, particularly in the setting of osteoporotic bone, medial calcar insuficiency and compromised vascularity of the humeral head. Four-part fractures according to the Neer classification are associated with high rates of fixation failure, AVN and functional outcomes, leading to increased interest in arthroplasty-based solutions. The present study compared rTSA with LP fixation and IFA augmentation in patients older than 65 years and demonstrated a consistent trend toward improved functional outcomes and lower

structural complication rates in the arthroplasty group, although statistical significance was not detected.

The functional results observed in this series are consistent with the growing body of literature supporting the use of rTSA for complex PHFs in elderly patients[3,4,5]. Reverse arthroplasty provides a biomechanical construct that is less dependent on rotator cuff integrity and humeral head vascularity, thereby allowing more predictable restoration of shoulder elevation and pain relief. Several comparative studies have reported superior CMS and improved forward elevation after rTSA compared with LP fixation in geriatric patients with three- and four-part fractures. In a propensity score–matched analysis, Tong et al. demonstrated more favorable rehabilitation progress and functional recovery following reverse shoulder replacement compared with internal fixation in elderly patients with complex fracture patterns[6]. These findings are in agreement with the present results, in which both absolute and relative CMS were consistently higher in the arthroplasty group.

Consistent superiority of arthroplasty across all functional metrics evaluated, including both Constant and DASH scores are reported across studies. Our results are in agreement with these results, although statistical significance was not detected.

LP fixation remains the golden standard in unstable PHFs when preservation of native shoulder joint is desired. However, fixation in osteoporotic bone is frequently compromised by medial column insufficiency, leading to varus collapse, screw cut-out, and secondary displacement. Augmentation with a fibular strut allograft has been proposed to address this biomechanical limitation by restoring medial support and increasing construct stiffness. A systematic review and meta-analysis by Nie et al. demonstrated that fibular strut augmentation significantly improves radiological alignment and reduces mechanical failure compared with plate fixation alone[7]. Similarly, Zhao et al. reported improved maintenance of reduction and functional outcomes when PHILOS fixation was combined with fibular allograft in elderly patients with three- and four-part fractures[8].

Despite these biomechanical advantages, the present study identified a substantial rate of AVN in the LP fixation group, affecting more than one-third of patients. This finding highlights the biological limitations of fixation in four-part fractures, where disruption of the anterior and posterior circumflex humeral arterial supply compromises humeral head viability. Even with anatomical or acceptable reduction and medial support, AVN remains a major cause of late failure after internal fixation. The high incidence of humeral head AVN observed in the current series is comparable to previously reported rates for complex fracture patterns treated with LP fixation.

RTSA addresses this biological limitation by eliminating dependence on humeral head perfusion. This may explain the lower rate of complications related to head viability observed in the arthroplasty group. Previous reports have shown lower revision rates after rTSA compared with osteosynthesis in elderly patients with complex PHFs. Greiwe et al. and Luciani et al. reported revision rates after internal fixation exceeding 30% in certain fracture subgroups, compared with approximately 9–15% following reverse arthroplasty[9,10]. In the present study, the overall reoperation rate was comparable between groups, but the underlying causes differed, with complications predominating after fixation and mechanical or infectious complications occurring after arthroplasty.

The complication profile observed in this study reflects the known risk patterns associated with each treatment strategy. LP fixation with IFA was associated primarily with AVN and tuberosity-related complications, whereas the arthroplasty group demonstrated occasional instability and infection. Importantly, no cases of scapular notching were identified at final follow-up, which may be related to the use of an onlay design and restoration of soft-tissue tensioning. Routine subscapularis repair and systematic tuberosity fixation may also have contributed to the relatively low instability rate observed.

Tuberosity healing remains an important determinant of rotational function after rTSA for fractures. Several authors have emphasized that successful tuberosity repair improves external rotation and overall functional scores[11,12,13]. The consistent use of tuberosity fixation in the present series may have supported the favorable functional outcomes achieved in the arthroplasty group.

Bone quality represents a critical factor influencing treatment selection and outcomes in PHFs. In the current study, the DTI values were comparable between groups, confirming that both cohorts consisted of patients with similar osteoporotic bone characteristics. Poor bone quality is a well-established risk factor for fixation failure and loss of reduction after LP fixation. The use of IFA augmentation aims to mitigate this risk; however, it does not fully address the biological vulnerability of the humeral head.

An important observation in the present study is that the reoperation rate did not differ substantially between groups. This finding suggests that both treatment strategies remain clinically acceptable when applied in appropriately selected patients. Therefore, treatment decisions should be individualized based on fracture morphology, bone quality, tuberosity reconstructibility, and patient functional demands.

The current literature contains relatively few direct comparisons between rTSA and LP fixation specifically augmented with fibular allograft. Most comparative studies evaluate arthroplasty against non-augmented fixation, which may underestimate the potential performance of modern reconstructive techniques. The present analysis contributes to the existing evidence by examining a fixation strategy designed to address the primary biomechanical weakness of osteoporotic fractures—loss of medial support.

From a clinical perspective, the results support the concept that rTSA may be particularly advantageous in fracture-dislocations, severely comminuted four-part fractures, and cases with compromised humeral head perfusion[15,16]. Conversely, augmented fixation may remain a reasonable option in patients with reconstructible tuberosities, especially when preservation of the native joint is preferred.

The study has several limitations. The retrospective design introduces potential selection bias, as treatment allocation was not randomized and may have been influenced by fracture characteristics or surgeon preference. The sample size limits statistical power and increases the risk of type II error. Additionally, heterogeneity in surgical techniques, including cemented versus uncemented stems and different surgical approaches, may have affected outcomes. Functional evaluation relied primarily on CMS and DASH scores without detailed range-of-motion analysis, which could have provided additional insight into rotational performance. Finally, the follow-up period, although exceeding two years on average, may not fully capture late complications such as prosthetic loosening.

Despite these limitations, the study has several strengths. The cohorts were comparable in age, sex distribution, and bone quality. Both groups received contemporary surgical techniques, including fibular strut augmentation and modern reverse arthroplasty design. The follow-up duration was sufficient to evaluate early and mid-term functional recovery and complication patterns. Importantly, the analysis addresses a clinically relevant question for which direct comparative data remain limited.

Future research should focus on prospective and randomized comparative studies with larger sample sizes. Incorporation of objective range-of-motion measurements, patient-reported outcome measures, and cost-effectiveness analyses would further clarify the optimal treatment strategy for elderly patients with complex proximal humerus fractures. In addition, longer-term follow-up is required to evaluate prosthetic survival and late complications after reverse shoulder arthroplasty performed for fractures.

5. CONCLUSION

The present study demonstrates that reverse total shoulder arthroplasty provides consistently higher functional scores and fewer complications related to humeral head viability compared with locking plate fixation augmented with intramedullary fibular allograft in patients > 65 years old with four-part proximal humerus fractures. Although statistical significance was not detected, the observed differences suggest potential clinical relevance. Both treatment options remain valid when applied according to appropriate indications. Careful patient selection remains essential for optimizing outcomes.

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