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Conversion to hemi-shoulder arthroplasty or reverse total shoulder arthroplasty after failed plate osteosynthesis of proximal humerus fractures: a retrospective study

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Abstract

Objective: To assess the clinical outcomes of hemi-shoulder arthroplasty (HSA) versus reverse total shoulder arthroplasty (RTSA) following failed plate osteosynthesis of proximal humerus fractures in elderly patients.

Methods: This retrospective study identified all patients that had a documented failed plate osteosynthesis of proximal humeral fractures treated with revision HSA or RTSA. Follow-up

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occurred at 1, 3, 6 and 12 months after surgery and every year thereafter. The primary outcomes were the American Shoulder and Elbow Surgeons (ASES) scores, Simple Shoulder Test (SST) scores, visual analogue scale (VAS) pain scores and the University of California, Los Angeles Shoulder Rating Scale (UCLA SRS) scores. The secondary outcome was the rate of major complications.

Results: A total of 126 patients (126 shoulders) were enrolled in the study. At the final follow-up, the RTSA group had significantly greater improvements in ASES, SST and UCLA SRS scores than the HSA group. The RTSA group had significantly larger decreases in the VAS pain score compared with the HSA group. The rate of major complications was significantly higher in the HSA group than in the RTSA group (44.4% versus 27.5%, respectively).

Conclusion: RTSA provided superior functional outcomes compared with HSA, with a lower rate of major complications after a follow-up period of at least 5 years.

Keywords

Hemi-shoulder arthroplasty, reverse total shoulder arthroplasty, proximal humerus fracture, outcome measurement

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Introduction

Proximal humeral fractures (PHFs) account for 5–6% of all adult fractures.[1–3] Approximately half of these fractures are displaced and comminuted, the majority of which involve the surgical neck.[4] Although there is a high incidence of varus positioning of the humeral head, avascular necrosis, screw cut-out, poor positioning of the plate leading to impingement, and failure of the construct associated with plate osteosynthesis, plate osteosynthesis remains the most widely used method of treating PHFs.[5–7] The treatment of failed plate osteosynthesis in elderly individuals remains challenging and controversial, and the alternatives include hemi-shoulder arthroplasty (HSA) and reverse total shoulder arthroplasty (RTSA).[8–10]

Hemi-shoulder arthroplasty is frequently utilized in degenerative conditions of the shoulder joint, a comminuted 3- or 4-part PHF with a high rate of avascular necrosis or fracture-dislocation according to Neer's system.[8,11] Prosthesis head subluxation or glenoid wear may contribute to persistent pain and limited shoulder function following HSA surgery.[8,12] Although HSA has absolute advantages in terms of operative time, blood loss and technical requirements compared with RTSA, the potential disadvantages, including the following aspects, cannot be ignored: further deterioration of the glenoid and frequent revision surgery or conversion to RTSA.[2,12] Evidence-based studies demonstrate that RTSA, a viable treatment option, was a successful procedure used to save failed plate osteosynthesis of PHFs.[11,13] However, it is unknown whether there is a distinct difference regarding the clinical and radiographic results between RTSA and HSA for the conversion of plate osteosynthesis.[9,14] To date, the optimal treatment strategy remains controversial.[14,15] Furthermore, to the best of our knowledge, few studies that directly compare HSA versus RTSA in older Asian individuals who initially received plate osteosynthesis of a PHF have been conducted.[8]

The purpose of this current study was to assess the clinical and radiographic outcomes of HSA versus RTSA following

failed plate osteosynthesis of PHFs in elderly individuals with a follow-up period of at least 5 years.

Patients and methods

Study design and patient eligibility

This retrospective study was undertaken in the Department of Orthopaedics, Jinshan Hospital, Fudan University, Shanghai, China and involved a retrospective review of all patients identified in the medical records database as having a documented failed plate osteosynthesis of PHFs treated with revision HSA or RTSA between January 2006 and January 2019. Patients with failed plate osteosynthesis of PHFs had documented rotator cuff integrity with clinical and magnetic resonance imaging to determine whether they should have an HSA or RTSA. The criteria for revision surgery were consistent with previous descriptions.[5,16,17] The inclusion criteria were as follows: (i) active individuals who were aged $\geq$50 years at the time of the HSA or RTSA surgery; (ii) no shoulder dysfunction or deformity prior to the fracture; (iii) able to follow a rehabilitation programme. The exclusion criteria were as follows: (i) a shoulder joint with severe vascular and nerve damage; (ii) a preexisting shoulder-related infection; (iii) non-healing wounds; (iv) pathological fractures or metastatic diseases; (v) an active infection; (vi) severe circulatory or medical diseases; (vii) incomplete study-related data; (viii) delirium or other cognitive impairments;[18] (ix) missing or poor pretreatment imaging data or inadequate medical records; (x) an injury severity score of $\geq$9; (xi) an American Society of Anesthesiologists Physical Status Classification System score of IV or V.

The primary outcomes were the American Shoulder and Elbow Surgeons (ASES), Simple Shoulder Test (SST), visual analogue scale (VAS) and University of California, Los Angeles Shoulder Rating Scale (UCLA SRS) scores. The secondary outcome was the rate of major complications. Follow-ups occurred 1, 3, 6 and 12 months after the HSA or RTSA surgery and every year thereafter.

This study was approved by the Institutional Review Board of Jinshan Hospital, Fudan University, Shanghai, China (no. 1162126). Patient informed consent was waived by the board due to the retrospective design of the study.

Surgical techniques

All HSA or RTSA procedures were performed by the same group of surgeons (M.Z., W.Y., J.Y. and G.H.). For the HSA-treated patients, a long deltopectoral exposure, leaving the anterior deltoid origin undamaged, was utilized. After removal of the initial fixtures, the humeral head was resected. The prosthesis with ingrowth material on the proximal aspect of the cemented stem (Trabecular Metal; Zimmer, Warsaw, IN, USA) was press-fit and implanted with supplementary distal cementation. The HSA procedure was based on those in previous reports.[11,19] The RTSA procedures were conducted per the Zimmer Reverse Anatomical Shoulder System (Zimmer).[11] All RTSA-treated patients were positioned in the beach chair position. A standard deltopectoral approach was applied in the RTSA procedures. The subscapularis muscle was exposed, detached and grasped with 0# ProleneTM sutures (Ethicon, New York, NY, USA). After the initial fixtures were removed, the humeral head was resected. A humeral component (cemented stem, Trabecular Metal reverse; Zimmer) with a cemented glenoid implant was implanted in all RTSA procedures, which was consistent with the descriptions in previous studies.[5,11,15] The size of the glenosphere was 36–42 mm.

The prosthesis selection was based on the patient's native osteological sizes as well as the conditions of the soft tissue and bone. Postoperative suction drains were performed for 48 h for each patient.

Postoperative rehabilitation

For HSA, the rehabilitation protocol included a shoulder immobilizer for 4 weeks. Pendulums and passive motion exercises were initiated within the first 24 h after surgery. At 5 weeks, a standard active-assisted motion programme was initiated, and then an active motion programme that progressed to include isometric strengthening was implemented. For RTSA, a shoulder sling was used for the first 4 weeks after surgery. During the 4 weeks, passive motion exercises were allowed. At 5 weeks, the shoulder immobilizer was discontinued and an active motion programme that progressed to include isometric strengthening, followed by activities of daily living, was initiated.

Definition of secondary outcome variables

The secondary outcome was the rate of complications, which consisted of glenoid component loosening, implant failure/revision, rotator cuff arthropathy, dislocation, scapular notching and symptoms of nerve stimulation. The definitions of glenoid component loosening, implant failure, dislocation, scapular notching, and symptoms of nerve stimulation were based on those in previous reports.[20,21] Revision as defined as failure of implants with clinical symptoms.[21] Rotator cuff dysfunction was defined in accordance with a previous description.[22]

Statistical analyses

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 24.0 (IBM Corp., Armonk, NY, USA). The primary outcomes were ASES, SST, VAS and UCLA SRS scores. The secondary outcome was the rate of complications. Statistical comparisons of the categorical variables were performed using χ^2-test. Continuous variables were compared using Student's *t*-test or Mann–Whitney *U*-test. A *P*-value < 0.05 was considered statistically significant.

Results

This retrospective study identified 215 consecutive patients with documented failed plate osteosynthesis of PHFs treated with revision HSA or RTSA. Of these, 89 were excluded and 126 patients met the inclusion criteria (Figure 1). Group HSA ($n = 62$) had a mean $\pm$ SD age of 63.37 ± 8.21years. Group RTSA ($n = 64$) had a mean $\pm$ SD age of 63.46 ± 8.77years. The eligible patients were centrally confirmed. The mean duration from the initial surgery to HSA or RTSA was 11.5 months (range 4–18 months). The mean follow-up was 5.8 years (range 5.0–6.5 years). No significant differences were found between the two groups in terms of baseline demographic and clinical data (Table 1).

In terms of the primary outcomes, data for the preoperative and postoperative outcome measurements for all patients are presented in Tables 2 and 3. At the final follow-up, improvement in functional outcome and pain levels was observed in both the HSA and RTSA groups. In group RTSA, improvements were achieved; and the mean $\pm$ SD ASES, SST and UCLA SRS scores increased to 67.3 ± 20.1, 7.8 ± 2.4, and 24.5 ± 5.5, respectively. In group HSA, improvements were also achieved; and the mean $\pm$ SD ASES, SST and UCLA SRS scores increased to 60.3 ± 19.5, 7.1 ± 3.7 and 22.1 ± 7.9, respectively. The improvements in these three measures in group RTSA were significantly larger than those in group HSA ($P < 0.05$ for each

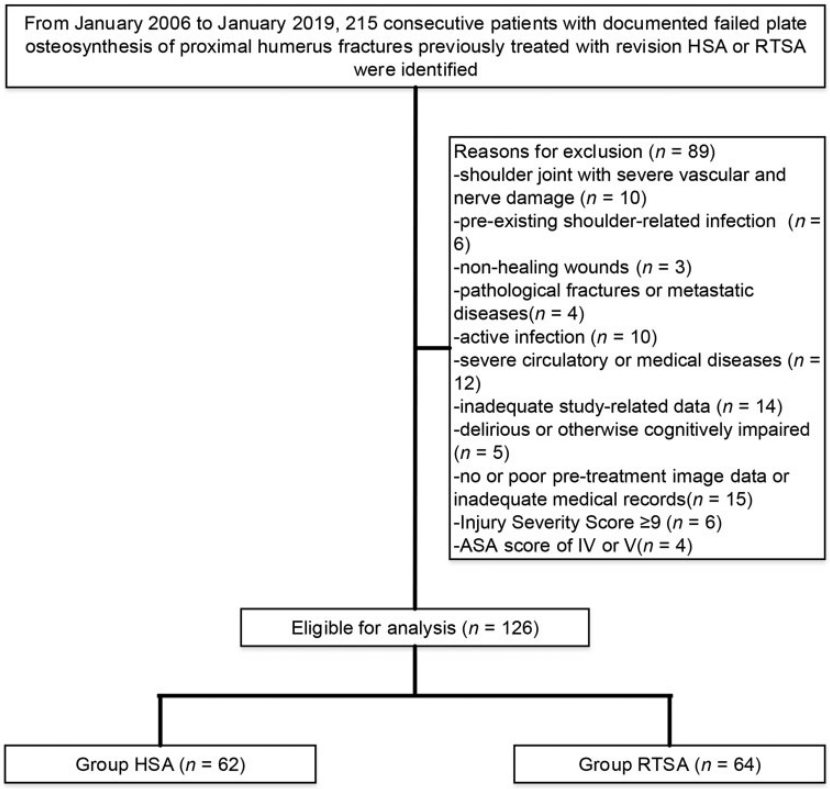

Figure 1. Flow diagram demonstrating methods for identification of patients to assess the clinical and radiographic outcomes of hemi-shoulder arthroplasty (HSA) versus reverse total shoulder arthroplasty (RTSA) following previous failed plate osteosynthesis of proximal humerus fractures in the elderly.

comparison). In addition, the VAS scores for pain decreased in both groups at the final follow-up, with mean ± SD values of 4.7 ± 2.1 and 3.4 ± 2.3 for the HSA and RTSA groups, respectively ($P = 0.027$).

In terms of the secondary outcome at the final follow-up, the rate of major complications was significantly higher in the HSA group than in the RTSA group (44.4% [32/(62+[32–22])] versus 27.5% [19/(64+[19–14])], respectively; $P = 0.037$) (Table 4). There were significant differences between the two groups in terms of the types of complications, including implant failure/revision, rotator cuff arthropathy and scapular notching ($P < 0.05$ for each comparison). Of these three types of complications, there were 19 in group HSA (eight had an implant failure or revision; 10 had rotator cuff arthropathy; and one had scapular notching); and there were 11 in group RTSA (no patients had an implant failure or revision; three had rotator cuff arthropathy; and eight had scapular notching).

Discussion

The results of this current retrospective analysis involving cohorts with PHFs treated with failed plate osteosynthesis, followed by a conversion to HSA or RTSA, indicate that RTSA has distinct advantages

Table 1. Baseline clinical and demographic characteristics of patients that underwent either hemi-shoulder arthroplasty (HSA) or reverse total shoulder arthroplasty (RTSA) following previous failed plate osteosynthesis of proximal humerus fractures.

Characteristic	Group HSA $n = 62$	Group RTSA $n = 64$
Sex, male/female	28/34	31/33
Age, years	63.37 ± 8.21	63.46 ± 8.77
Body mass index, kg/m^2	25.76 ± 8.53	25.67 ± 9.38
Bone mineral density	-2.65 ± 0.86	-2.72 ± 0.69
Side affected, left/right	32/30	30/34
Comorbidities		
Hypertension and/or diabetes mellitus	11	13
Pulmonary	8	7
Cerebrovascular accident	5	6
Other	12	13
Mechanism of injury		
Traffic-related injury	30	31
Injury by falling	24	22
Other	8	11
Causes for revision		
Screw cut-out	22	25
Humeral head necrosis	12	16
Glenoid destruction	28	23
ASA score		
I	10	12
II	35	30
III	17	22
Hamada grade		
1	11	9
2	14	16
3	21	17
4	16	22
Glenoid erosion		
None	17	14
Mild	11	13
Moderate	22	26
Severe	12	11
Time between the 1st to the 2nd surgery, months	11.63 ± 7.32	11.36 ± 6.51
Follow-up period, months	69.22 ± 8.81	69.24 ± 8.74

Data presented as mean $\pm$ SD or *n* of patients.
No significant between-group differences ($P \geq 0.05$); categorical variables were compared using χ^2-test; continuous variables were compared using Student's *t*-test or Mann–Whitney *U*-test.
ASA, American Society of Anesthesiologists.

over HSA. Despite being regarded as the standard of care by the majority of individuals in some medical institutions,[16,18] HSA appeared to be deficient in this current study, although it was associated with less scapular notching than RTSA. RTSA demonstrated significant improvements over HSA in terms of the functional outcomes.

These current findings were in accordance with those reported in several

studies[14,23] and demonstrated that RTSA significantly improved the functional outcomes of failed plate osteosynthesis compared with HSA. Theoretically, RTSA has many advantages over HSA in treating PHFs.[24] The functional outcomes of RTSA appear to depend less on rotator cuff integrity than those of HSA; and faster postoperative recovery and fewer rehabilitation requirements were observed for HSA.[25] Although RTSA is mainly performed in elderly individuals with declining functional requirements of the shoulders, the prerequisite for potential benefits from RTSA is not restricted to this population. RTSA has been recommended as an alternative to HSA.[8,9] However, the therapeutic significance of RTSA in treating failed plate osteosynthesis is a matter of great debate.[5,16] Limited evidence is available on to the conversion to HSA or RTSA in such patients. Few reports have focused on HSA or RTSA following failed plate osteosynthesis for PHFs.[5,16] To date, few studies have investigated the therapeutic role of HSA or RTSA following failed plate osteosynthesis in Asian individuals with PHFs. A previous influential review demonstrated a lack of evidence available to identify the optimal treatment method for failed plate osteosynthesis.[26] However, as there is no clear optimal treatment, the choice of a definitive treatment for failed plate osteosynthesis tends to be at the discretion of the surgeons, and consequently, avoiding abundant variability among these surgeons is quite difficult.[27] A previous study that described a cohort of 53 patients (54 shoulders) with PHFs treated with a failed plate osteosynthesis, followed by RTSA, with a minimum follow-up of 2 years demonstrated that the mean absolute Constant–Murley score

Table 2. Preoperative outcome measurements of the primary outcomes for patients that underwent either hemi-shoulder arthroplasty (HSA) or reverse total shoulder arthroplasty (RTSA) following previous failed plate osteosynthesis of proximal humerus fractures.

Outcome measures	Group HSA $n = 62$	Group RTSA $n = 64$
ASES score	24.2 ± 14.3	24.3 ± 15.1
SST score	1.6 ± 1.7	1.6 ± 1.8
VAS pain score	7.2 ± 3.3	7.1 ± 2.8
UCLA SRS score	7.3 ± 2.7	7.4 ± 2.5

Data presented as mean ± SD.
No significant between-group differences ($P \geq 0.05$); continuous variables were compared using Student's *t*-test or Mann–Whitney *U*-test.
ASES, American Shoulder and Elbow Surgeons; SST, Simple Shoulder Test; VAS, visual analogue scale; UCLA SRS, University of California, Los Angeles Shoulder Rating Scale.

Table 3. Postoperative outcome measurements at final follow-up for patients that underwent either hemi-shoulder arthroplasty (HSA) or reverse total shoulder arthroplasty (RTSA) following previous failed plate osteosynthesis of proximal humerus fractures.

Outcome measures	Group HSA $n = 62$	Group RTSA $n = 64$	Statistical analysis[a]
ASES score	60.3 ± 19.5	67.3 ± 20.1	$P = 0.031$
SST score	7.1 ± 3.7	7.8 ± 2.4	$P = 0.033$
VAS pain score	4.7 ± 2.1	3.4 ± 2.3	$P = 0.027$
UCLA SRS score	22.1 ± 7.9	24.5 ± 5.5	$P = 0.014$

Data presented as mean ± SD.
[a]Continuous variables were compared using Student's *t*-test or Mann–Whitney *U*-test.
ASES, American Shoulder and Elbow Surgeons; SST, Simple Shoulder Test; VAS, visual analogue scale; UCLA SRS, University of California, Los Angeles Shoulder Rating Scale.

Table 4. Secondary outcome measurement of major complications at long-term follow-up for patients that underwent either hemi-shoulder arthroplasty (HSA) or reverse total shoulder arthroplasty (RTSA) following previous failed plate osteosynthesis of proximal humerus fractures.

Outcome measure	Group HSA $n = 62$	Group RTSA $n = 64$	Statistical analysis[a]
Major complications	32 (44.4[b])	19 (27.5[c])	$P = 0.037$
Patients affected	22 (35.5)	14 (21.9)	NS
Type of complication			
Glenoid component loosening	6	2	NS
Implant failure/revision	8	0	$P = 0.005$
Rotator cuff arthropathy	10	3	$P = 0.035$
Dislocation	3	4	NS
Scapular notching	1	8	$P = 0.018$
Symptoms of nerve stimulation	4	2	NS

Data presented as *n* of patients (%).

[a]Categorical variables were compared using χ^2-test; [b]32/(62+[32–22]); [c]19/(64+[19–14]); NS, no significant difference ($P \geq 0.05$).

improved from 26 (range 4–54) to 55 (range 19–80) points.[5] Similarly, a case–control study including 27 patients with a mean ± SD follow-up of 4.9 ± 1.2 years showed that RTSA appears to enable a superior range of motion earlier than HSA.[11] The reported functional outcomes have been favourable, including those from a recent randomized study,[28] which demonstrated that RTSA was superior to HSA in treating PHFs according to the patients' functional outcomes.

Reverse total shoulder arthroplasty, which was initially introduced to treat rotator cuff arthropathy, is a challenging procedure.[2,4] A growing but still very limited body of literature has demonstrated that RTSA is superior to HSA in regard to the functional outcomes.[6,28] Furthermore, data from this current analysis indicate that the functional outcomes with HSA were inferior to those provided by RTSA regarding the occurrence of rotator cuff arthropathy. Previous studies showed that rotator cuff arthropathy occurred in 54 cases (42%) and correlated the occurrence of rotator cuff arthropathy with an unacceptable result: when the upper arm straightened the shoulder joint for internal rotation and abduction, tenderness between the large nodule and the shoulder peak was palpable.[3,5,16] When the rotator cuff was completely broken, the shoulder joint abduction function was seriously affected by the loss of the stabilizing effect on the humeral head;[11] when the rotator cuff is partially torn, patients can still abduct the upper arm, but the range of motion between 60° and 120° is painful.[4,22]

The present study had several limitations. First, the current study was a retrospective analysis with inevitable challenges inherent to the methodology. Potential confounders may exist in the current study, but the ability to draw reliable conclusions from the well-matched cohorts was not directly related to the baseline characteristics. Secondly, the findings of this current analysis cannot be generalized to all individuals with failed plate osteosynthesis due to the small but significant between-group age differences. Thirdly, in the initial analyses, several variables were accounted for, but residual confounding effects were not identified.

In conclusion, in patients with PHFs treated with failed plate osteosynthesis, RTSA was superior to HSA regarding the functional outcomes, with a lower rate of major complications after a follow-up period of at least 5 years. Although there are many challenges and limited surgical options for the treatment of failed plate osteosynthesis of a fracture of the proximal humerus, an improvement in the functional outcome can be expected when performing an RTSA as a salvage procedure.

Declaration of conflicting interest

The authors declare that there are no conflicts of interest.

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