Outcome of geriatric proximal humeral fractures: a comparison between reverse shoulder arthroplasty versus open reduction and internal fixation

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Abstract

**Objectives:*** In view of the increased attention to reverse shoulder arthroplasty (rTSA) as a treatment for complex proximal humeral fractures in the elderly, the present study analyzes in-hospital complications and the postoperative management of rTSA versus open reduction and internal fixation (ORIF).

**Methods:** We retrospectively reviewed patients hospitalized from 2016 to 2018 for proximal humeral fractures (ICD-9 codes: S42.21), III- and IV-part, who underwent an ORIF with locking plates, rTSA or nonoperative treatment. In-hospital complications and postoperative management in both groups were included in the analysis.

**Results:** We included n = 190 patients (ORIF = 90, rTSA = 71, nonoperative = 29), more likely to be female (82.1% vs 17.9%; P < .01) with an average age of 82 years (min. 72, max. 99; SD 6.4). The ORIF and the rTSA groups showed comparable complication rates (15.6% vs 15%; P = .87) but with a significantly shorter hospital stay (8.6 vs 11.5 days; P = .01) and shorter duration of surgery (72.9 vs 87.2 minutes; P = .01) in the ORIF group. Significantly more patients after ORIF achieved an independent life postoperatively (53.3% vs 40.8%; P = .013).

**Conclusions:** In this retrospective analysis, ORIF is related to a shorter duration of surgery, a shorter hospital stay and a higher likelihood of independence. Despite the popularity of the rTSA, ORIF remains a reliable treatment option for proximal humeral fractures in the elderly.

**Level of evidence:** III

**Keywords:** complications, delirium, elderly, geriatric patients, proximal humeral fractures

1. Introduction

Fractures of the proximal humerus are common in elderly osteoporotic patients, which are most commonly women.[1] The majority of elderly patients with proximal humeral fractures can be treated nonoperatively. However, displaced osteoporotic fractures may result in compromised upper extremity function that impairs the patient’s ability to care for themself.[2–5] Given the steadily increasing incidence of proximal humeral fractures in the elderly, optimal treatment methods have to be better defined so that the outcomes are improved and long-term costs to society minimized.[1] Improvement of results begins with the correct initial indication for surgery.[6] This is especially relevant for patients with displaced 3- and 4-part proximal humeral fractures. If surgical treatment is required, the treatment options in this patient group include open reduction and internal fixation (ORIF), hemi- and total arthroplasty, and reverse shoulder arthroplasty (rTSA). According to available data, numerous studies document good functional scores and acceptable complication rates after both primary rTSA and internal fixation for proximal humeral fractures in the elderly, but there appears to be a growing consensus that complication rates are in general lower and function better after rTSA.[7–15] However, only a few studies report the outcomes after proximal humeral fractures with regards to patients’ ability to live independently, which is an outcome of significant importance.[3,4,16] Hence, the purpose of this study was to review...
results after primary rTSA and compare the outcomes of ORIF and nonoperative treatment for proximal humeral fractures. We hypothesized that despite reliable clinical outcome described for rTSA, ORIF may remain a reliable treatment option with regard to maintaining their independence after sustaining a proximal humerus fracture.

2. Materials and methods

2.1. Patients

In the present retrospective study, patients with 3- or 4-part humeral fractures according to the Neer classification from 2016 to 2018 were retrospectively identified by ICD-codes (S42.21) (Fig. 1). The inclusion criteria were 3- or 4-part fractures and patients age greater than 70 years. Excluded were patients with dementia or pathological fractures.

A complete clinical history was obtained. The clinical history also included the history of rehabilitation. All the participants were discharged to either home, rehabilitation facility or nursing home. After rehabilitation, the patients were discharged home, to a short-term nursing home, nursing home, or to another hospital according to other comorbidities. The level of home care was obtained for all patients preoperatively and at follow-up. Information about comorbidity was obtained by ASA-Score for the rTSA and ORIF group in 127 cases. Intra- and post-operative complications were noted. The author discloses that the present study was approved by the local committee on research ethics at the University of Bonn in which the research was conducted in accordance with the Declaration of the World Medical Association (www.wma.net) and that any informed consent from human subjects was obtained as required.

2.2. Surgical procedure

All procedures were performed in a single-center, with the patient under general anesthesia and in the beach-chair position using a standard deltopectoral approach. The patients in the ORIF and rTSA group were operated on a uniform surgical technique as follows.

In the rTSA group, a reverse shoulder prosthesis (DeltaXtend, Johnson & Johnson) was implanted within a maximum term of 7 days from the date of the injury (Fig. 2). After tenotomy of the long biceps tendon, preparation of the greater and lesser tuberosities followed. In all cases, tuberosity reattachment was performed with a suture configuration that included 2 horizontal sutures and 2 vertical cerclages (from diaphysis to greater tuberosity and from diaphysis to lesser tuberosity) with a heavy nonabsorbable braided suture (FiberWire, Arthrex, Naples Florida). Supraspinatus excision was done before tuberosity reattachment.
The glenoid was prepared for the metaglene, and the metaglene was positioned and fixed with 2 3.5-mm locking and 2 3.5-mm non-locking screws; a standard size metaglene (13.5 mm) was used in all cases. A centric or eccentric 42 mm—glenosphere was applied to match the anatomy of individual patients. For all patients the same size of the glenosphere (42 mm) and offset was used. Lateral offset was used depending on the joint stability. The humeral canal was then reamed and a standard-length humeral stem was cemented. The cement (Palacos R.G; Heraeus GmbH, Wehrheim, Germany) was prepared with the use of a vacuum mixing device (Palamix; Heraeus GmbH) following the instructions of the manufacturer. Intramedullary plugs were used in all cases to increase the cement-bone interface pressure during the insertion of the humeral component. rTSA was performed by a single surgeon (CP).

The patients in the ORIF group underwent open reduction and internal stabilization by using a locking plate (Johnson & Johnson, Synthes, PHILOS, West Chester, Pennsylvania). The average time between initial fracture incident and ORIF was within 3 days. If possible, additional tuberosity fixation with a FiberWire attached to the locking plate was performed. Strut grafts or any other sort of bone augmentation was not used.

In the rTSA and ORIF group, the postoperative rehabilitation protocol included early passive motion without limits according to pain tolerance starting after the first postoperative day. After 2 months, the patients are allowed to start strengthening the shoulder.

The third group was treated nonoperatively. The rehabilitation protocol included a sling for 4 weeks and early passive motion started after the first week.

2.3. Clinical outcome criteria

Perioperative data included the ASA-Score, the duration of surgery in minutes and hospital stay in days. The purpose of the ASA Physical Status Classification System is to assess and communicate a patient’s per-anesthesia medical comorbidity. The rate of complications was determined retrospectively for all patients. For the rTSA group, typical postoperative complications were infection, nerve lesions, and instability. Typically, complications in the ORIF group were osteonecrosis and failure of osteosynthesis. The mortality and the postoperative rate of delirium were observed for all patients.

Posthospital data collected included the day of discharge from hospital and patient disposition (home, nursing home, or rehabilitation facility primarily for the elderly). In the latter group, we also recorded the final patient disposition after discharge from the rehab facility.

2.4. Radiological outcome

A radiologic assessment was performed for all patients pre- and post-operatively. It was based on a true anteroposterior view and scapular lateral view of the shoulder (Fig. 2). In all cases, CT-scans were obtained. A trained radiologist was unaware of the patient’s clinical features’ and reviewed each patient’s radiographic studies. The radiographs were graded as previously described by Neer. The quality of the humeral bone was preoperatively evaluated by the Deltoid Tuberosity Index (DTI). The DTI was measured on the true anteroposterior view by a single observer (Fig. 3A). Additionally, the critical shoulder index was measured on the anteroposterior view (Fig. 3B).

2.5. Statistical analysis

For statistical analysis SPSS Statistics was used. The Kolmogorov-Smirnov test determined normal distribution. Mann-Whitney U test and Chi-quadrat-Pearson were performed to detect any significant statistical differences. We used descriptive statistics to summarize mean and standard deviations. Pearson test was used to detect a correlation. The level of significance was defined as a P value of < .05.
3. Results

3.1. Patients

Two hundred forty-four patients with 3- or 4-part proximal humeral fractures according to the Neer classification were identified; 190 met the inclusion/exclusion criteria and form the basis for this study. Fifty-four patients with dementia or pathological fractures were excluded. Patients were treated by ORIF (n=90), ORIF (n=71), or nonoperatively (n=29). The average age was 82.3 years (min. 72, max. 99), 78.9% female in the ORIF group, 84.4% female in the RSA group, and 87 years (min. 72, max. 98, SD 6.73; 82.8% female) in the nonoperative group.

4. Outcome criteria clinical

4.1. Intrahospital management

The ASA-Score was gathered in 127 cases (I:3.9%, II:35.8%, III:26.3%, IV:2.1%). There was no significant difference between the ORIF and the RSA group. The duration of surgery in the ORIF group was 72 minutes (min. 36, max. 150, SD 30.22), and in the rTSA group 87.3 minutes (min. 42 max. 154, SD 25.23) (P=0.01). The hospital stay was 8.7 (min. 1, max. 22, SD 5.19) versus 11.5 (min. 3, max. 29, SD 4.41) days (ORIF vs rTSA) (P=0.01). Both parameters, hospital stay and duration of surgery, were significantly shorter in the ORIF group (P=0.01).

4.2. Complications

Table 1 summarizes the main results. In the rTSA group, the rate of complications was 15% (n=11) including hematomas (1), infection (1), limb lesions (2), delirium (4), and death (2). Two out of 71 patients (2.8%) received a secondary surgery. One patient had a hematoma in the first 24 hours and the other an infection, both followed by revision surgery with changing the mobile components, inlay and glenosphere (2 weeks). In the ORIF group a similar complication rate was observed (15.6%, n=15) including hematomas (2), necrosis (5), and failure of the osteosynthesis (8). In the ORIF group, 11.1% of the patients had revision surgery. Necrosis was reported after 3 months and 1 year and failure of osteosynthesis was observed in the first 3 months postoperatively. The reasons for revision were failure of osteosynthesis (8) and osteonecrosis (2). Revision procedures included a removal of the plate (2) or implantation of a reverse shoulder prosthesis (8). There was no death or delirium in the ORIF group. In the rTSA group, the mortality rate was 2.8%, and the delirium rate was 5.6%.

4.3. Postdischarge data

In the ORIF group, 53.3% (n=48) of patients were discharged back home, 43.3% (n=39) to a geriatric early rehabilitation facility, and 3.3% (n=3) to a nursing home. Of the patients who were discharged for early geriatric rehabilitation, 23.3% (n=21) reached their home again after the rehabilitation. The remaining patients were discharged to another hospital (n=3), nursing home (n=1), short-term nursing (n=3), or not reported (n=11). Table 2 and Figure 4 summarizes the main results.

In the RSA group, 40.8% (n=29) of patients were discharged to their home, geriatric early rehabilitation facility (n=32), or to a new nursing home (n=9). After rehabilitation, the patients were able to go backhome (n=11), to a new nursing home (n=2), another hospital (n=1), and short-term nursing (n=10); the others (n=8) were not reported. Patients treated conservatively were discharged back home (n=9), to a geriatric early rehabilitation facility (n=11), a nursing home (n=7), or another hospital (n=1). After the rehabilitation, the patients were able to go back home (n=4), the others were discharged for short-term nursing (n=2) or another hospital (n=2), or missing data (n=3). Patients after ORIF were more often discharged to their home compared to patients after rTSA. The outcome parameter “discharged home” was significantly different between both groups (ORIF vs rTSA) after early geriatric rehabilitation (P=0.019) indicating that ORIF in conjunction with early geriatric rehabilitation serves for an improved outcome with respect to living at home.

4.4. Radiological outcome

The mean measured DTI was 1.4 in the rTSA group (min. 1.2, max. 1.7, SD .12) and in the ORIF group (min. 1.2, max. 1.8, SD 1.13) (n.s.). A correlation between ASA and procedure or DTI and procedure could not be observed.

5. Discussion

Fractures of the proximal humerus are common in elderly osteoporotic patients, and displaced osteoporotic fractures
especially pose a risk for self-sufficient care. Improvement of results begins with the correct initial indication for surgery. Two major conclusions, which are largely in agreement with our hypotheses, can be drawn by considering the outcomes of the present retrospective study. First, rTSA and ORIF after proximal humeral fractures in the elderly have similar rates of complications. Second, duration of surgery and hospital stay were significantly lower in the ORIF group compared to the rTSA group. The majority of the patients after ORIF were discharged back home. However, the ORIF group has a higher rate of revision. In the case of preferring ORIF, the risk of a secondary surgery remains. 

There are limitations to this study due to its retrospective methodology. Some key statistics cannot be determined, and clinical biases may have affected the selection of patients. A further criticism is a missing algorithm for the treatment of the initial proximal humeral fractures. Allocation to rTSA, ORIF, or nonoperative treatment was based on the subjective judgment of the surgeon. However, the present study was a single-center study, and the allocation based mainly on the judgment of 1 person (CP). Moreover, the preoperatively measured ASA-Score as an indicator for comorbidities has shown no significant difference between the groups. So, we do not believe that selection bias was a major factor in decisions about patient treatment.

Several studies have reported on reliable clinical outcomes after primary rTSA for proximal humeral fractures. However, just a few studies focused on complications in the elderly. The present study has shown that patients after rTSA and ORIF have similar rates of complications. However, the revision rate was significantly higher in the ORIF group. Klug et al found significantly fewer complications and revisions after rTSA despite superior functional outcomes after ORIF. Also, Wincheringer et al observed fewer complications after rTSA compared to ORIF in the elderly. 

Compared to our results, Giardella et al showed fewer complications in both treatment options. However, better clinical and daily living results were reported in rTSA compared with ORIF. In spite of the similar rates of complications, the present study has observed a lower revision rate after rTSA. Also, Luciani et al have observed that both treatments showed good clinical outcomes, but rTSA resulted in a lower revision rate than ORIF.

The majority of the patients after ORIF were discharged back home. Our results have shown that 76.7% of patients in the ORIF and 56.3% in the rTSA group could be discharged home including the time which some of the patients needed for early geriatric rehabilitation. Therefore, patients treated with ORIF alone or in combination with early geriatric rehabilitation have a higher chance to reach their previous level of activity and independency at home. In contrast to our results, recent studies have reported better clinical and daily living results for rTSA treatment in conjunction with a higher rate of complications. 

Rotman et al have observed no significant difference in 1-year mortality between patients with rTSA versus patients treated conservatively, although there was a trend towards a lower mortality in the operative group. After 6 months, 84% of the patients after rTSA for proximal humeral fractures were back at their previous level of activity. In the present study, the hospital stay was significantly shorter and the subsequent risk of losing independence was lower in the ORIF group. In contrast to the rTSA group, no delirium was observed in the ORIF group. It should be pointed out that postoperative delirium is associated with increased morbidity and mortality, postoperative cognitive decline and long-term dementia, poor functional recovery, prolonged hospitalization, and increased nursing home admission. Delirium is the major driving force to become dependent at advanced age. Therefore, to choose wisely for an operative strategy which is related to a low incidence of delirium is of utmost importance.

Einsiedel et al showed a high incidence of “fear of falling” for patients with proximal humeral fractures in the elderly, and 17% of these patients had to give up an independent household. There was a significant worsening in the ability to walk after an injury, leading to 2 or more new falls in 28%. Taking these observations into consideration, the optimal treatment for proximal humeral fractures in the elderly remains a key factor to
avoid a prolonged hospitalization and poor functional recovery. Preventing second surgery and delirium and striving for short duration of surgery and limited hospital stay is the basis for good clinical outcome and functional independency. The lower revision rate after rTSA may support the avoidance of a second surgery. However, rTSA may result in prolonged hospitalization and longer duration of surgery which could increase the risk of a postoperative delirium. Besides the fracture type, these considerations have to be taken into account in the treatment of proximal humeral fractures at advanced age. Overall, the present study aims to evaluate the consequences and outcome of a proximal humeral fracture at advanced age. In spite of the reliable clinical outcome of rTSA, ORIF should remain an established option.

6. Conclusions

In conclusion, rTSA and ORIF are effective treatments for proximal humeral fractures in the elderly. In spite of the popularity of the rTSA, ORIF will remain a reliable option and provides a high likelihood of functional independence when combined with early postoperative geriatric rehabilitation. However, ORIF represents a higher risk of secondary surgery. In contrast, rTSA is related to a longer hospital stay and duration of surgery that may bear a higher risk for delirium.

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