Reverse shoulder arthroplasty for complex fractures of the proximal humerus in elderly patients: impact on the level of independency, early function, and pain medication

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\textbf{Background:} This study investigated early functional outcome, quality of life, and the level of independency in elderly patients after primary reverse shoulder arthroplasty (RSA) for complex fractures of the proximal humerus.

\textbf{Methods:} This was a prospective case series that included 33 patients, aged $\geq 70$ years, with a high level of independency who received RSA for complex fractures of the humerus (Orthopaedic Trauma Association B2/C) from January 2012 to April 2014.

\textbf{Results:} Level of independency, quality of life (Short Form 36 Health Survey score), early functional outcome (Constant-Murley score, Disabilities of the Arm, Shoulder and Hand Outcome Measure), and pain medication (World Health Organization grading) were obtained at the 6-month follow-up and 1 year after surgery. The Constant-Murley score was $64 \pm 14$ after 6 months and $71 \pm 12$ at 1 year ($P < .001$), reaching 87\% compared with the contralateral shoulder. The Disabilities of the Arm, Shoulder and Hand score reached $29 \pm 20$ at 6 months and $30 \pm 21$ at 1 year. The Short Form 36 score was comparable to normative data. After 6 months, 84\% of our study group were back at their previous level of independency. Within 1 year, this rate increased to 91\%. At the 1-year follow-up, analgesia intake was back at the level before the injury in 97\% of the patients.

\textbf{Conclusions:} Primary RSA provides good early functional results, reliable pain control, and excellent restoration of an independent life style in elderly patients. Thus, RSA may be considered for active patients with a high demand on shoulder function.
Fractures of the humeral head are among the most common fractures in elderly patients. The treatment of these fractures is known to be prone to various complications, such as humeral head necrosis and loss of function of the rotator cuff. Thus, functional outcome is frequently poor.

A relevant decrease of shoulder function may be associated with a decreased quality of life and a potential loss of an independent life, in particular for elderly patients. For these patients, the preservation of an independent life is the most important goal among others such as function, pain control, and a low complication rate. Preservation of an independent life may also be the most important factor to lower overall costs. Thus, not only purely functional outcome but also the degree of an independent life should be taken into consideration for the assessment of different therapeutic modalities for complex fractures of the proximal humerus.

The purpose of this study was to prospectively assess reverse shoulder arthroplasty (RSA) as the primary treatment option in elderly patients with complex fractures of the humeral head, focusing on early functional outcome and its influence on potential social implications such as a partial or total loss of independence. Our hypothesis was that RSA may provide good functional results associated with preservation of the patient’s social situation as it presented before trauma.

Materials and methods

Patients

This prospective single-center study included all patients aged ≥70 years who were treated with primary RSA for acute complex fractures of the proximal humerus between January 2012 and April 2014. Fracture patterns treated with RSA included 3- and 4-part fractures according to Neer or 11-B and 11-C fractures according to the Orthopaedic Trauma Association (OTA)/Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification, respectively. These fracture patterns are generally associated with a high risk of subsequent avascular necrosis of the humeral head. Patients aged <70 years and patients with RSA for sequelae of failed nonoperative treatment, osteosynthesis, or fracture hemiarthroplasty (HA) were excluded (n = 10) from further evaluation. Informed consent was obtained from all patients entering the study and for the operative treatment and the follow-up investigations.

Preoperative assessment

The preoperative evaluation included a clinical examination and the patient’s history, with a focus on the pretraumatic shoulder function and the preoperative way of life. The level of independence was defined as follows: independently living at home, depending on some help at home, living in a retirement home, living in a nursing home with additional support. Only patients with higher levels of independence (living at home or in a retirement home) were included, patients living in a nursing home were excluded. The use of analgesia before trauma was recorded and classified according to the official World Health Organization (WHO) analgesic ladder.

All patients received a standard series of x-rays (true anteroposterior, posterior and lateral views, scapular Y view). All fractures were additionally assessed by a computed tomography (CT) scan (128-slice technology with 3-dimensional reconstructions) for a better understanding of the injury regarding fracture classification and potential compromise of humeral head perfusion.

Operative technique and rehabilitation

All patients received the same RSA model (Acqualis-Reversed Fracture; Tornier S.A.S., Montbonnot Saint Martin, France). All operations were performed with the patient in the beach chair position by the second (P.G.) or last (C.M.) author. General anesthesia was combined with a continuous interscalene block in all patients.

A standard deltopectoral approach was used. The base plate was attached to the glenoid surface in an inferior position with a 10° inferior tilt. The stem was placed in the proximal humerus using third-generation cementing technique (TBcement G1, Tornier) in the determined height and a retroversion of 25°. Tuberosity fixation was performed with 4 doubled-over struts of strong nonabsorbable braided polytetrafluoroethylene-impregnated polyester suture (Nicol-Loop, Tornier) according to the technique described by Boileau et al. Cancellous bone grafts harvested from the resected humeral head were used to fill any remaining osseous defects.

All patients were immobilized postoperatively on an abduction pillow (30°) for 6 weeks. Patients were encouraged to perform active wrist and elbow movements from the beginning, but no mobilization of the shoulder was allowed for 6 weeks. This was followed by physiotherapy of the shoulder with free active range of motion. Strengthening exercises were started at week 13.

Follow-up

Intraoperative and postoperative complications and reinterventions were recorded. Follow-up investigations were performed after 6 and 12 months. The clinical evaluation included the Constant-Murley score (CMS), the age-adjusted and gender-adjusted CMS and the CMS of the contralateral shoulder were assessed as well. The Disabilities of the Arm, Shoulder and Hand (DASH) Outcome Measure and Short Form 36 Health Survey (SF-36) questionnaires were completed by the patients at home after receiving proper instructions by the investigators and were returned by mail. The social situation and intake of analgesic medication were assessed using the...
definitions described above. In addition, the patients were asked to rate their level of satisfaction as excellent, good, fair, or poor.

All patients underwent a standardized radiographic evaluation at follow-up, including a true anteroposterior radiograph in neutral rotation, a scapular Y view, and an axillary view. X-ray series were analyzed for signs of scapular notching and implant loosening as well as the quality and position of the tuberosities after 1 year. Scapular notching was defined according to Levine et al. Bone loss was graded according to the Sirveaux classification. Bone resorption of a tuberosity was defined as partial (size <50% in relation to the initial postoperative radiographs) or complete. Displacement was defined as migration >5 mm compared with the postoperative radiographs. All follow-up investigations were performed by the second (P.G.) or last (C.M.) author. X-ray images were also analyzed by these 2 authors and a senior radiologist who was not involved in other aspects of the study.

Statistical evaluation

A statistical analysis was performed using IBM SPSS Statistics for Windows 21.0 software (IBM Corp., Armonk, NY, USA). A paired t test was used to compare the different scores at the 6-month and 1-year postoperative follow-up assessments. Spearman rank correlation analysis was performed to study the relationship between functional outcome and the resorption of the tuberosities. The significance level was set at P < .05.

Results

Patients

Between January 2012 and April 2014, 33 consecutive patients could be included. Mean age was 80 ± 6 years. There were 5 men and 28 women (85% female). According to the Neer classification, there were 15 three-part, 17 four-part fractures, and 1 anterior dislocation with an associated 4-part fracture. Applying the OTA/AO classification, we recorded 8 B2, 24 C2, and 1 C3 fractures. All fractures were the result of a low-energy trauma. The dominant shoulder was affected in 12 patients (36%). The mean interval between injury and surgery was 7 ± 5 days (range, 2-20 days) in our study group. The indication for RSA in 30 patients was based on the initial fracture pattern. Surgery was performed in 3 patients after early secondary fracture displacement. Intraoperatively, a complete tear of the supraspinatus tendon was seen in 12 patients (36%), and the infraspinatus was torn in 3 (9%). One patient (3%) presented with a tear of the upper third of the subscapularis tendon. Mean hospital length of stay was 13 ± 5 days (range, 8-32 days).

Complications

A single cerclage of the proximal humeral shaft had to be performed in 3 patients (9%) as a result of an iatrogenic fracture after reaming. All of these fractures healed uneventfully. No other intraoperative complications were recorded.

We observed neither any implant-related postoperative infection nor any relevant hematoma. No revision operations were performed.

Follow-up

Of the initial 33 patients who were enrolled in this series, 32 (97%) were available for the 1-year follow-up assessment. All of these patients had a complete follow-up investigation, including clinical evaluation and radiologic assessment. One patient (3%) was not available for the 1-year follow-up due to a serious medical condition. Two patients (6%) missed their clinical and radiologic evaluation after 6 months; however, their social situation and analgesia intake were retrospectively assessed.

Shoulder function and pain

The overall functional score results are reported in Table I. The mean absolute and relative CMSs both demonstrated a significant improvement after 12 months compared with the first follow-up after 6 months. The DASH scores showed no significant change over time.

Before the trauma, most patients had not been regularly using analgesic medication (Table II). The use of analgesics

| Table I | Functional scores |
|---------|-------------------|-------------------|-------------------|
| Score   | 6-month follow-up | 1-year follow-up  | P value          |
| CMS5    |                   |                   |                  |
| Total (maximum 100 points) | 64 ± 14 (35-84) | 71 ± 12 (46-94) | <.001            |
| Pain (15 points) | 12 ± 4 (1-15) | 13 ± 3 (4-15) | .152             |
| Activity level (20 points) | 17 ± 4 (9-20) | 18 ± 3 (10-20) | .005             |
| Range of motion (40 points) | 25 ± 6 (12-38) | 28 ± 5 (18-40) | <.001            |
| Strength (25 points) | 10 ± 4 (5-18) | 13 ± 5 (4-25) | <.001            |
| CMS relative to age- and gender-adapted score,37 % | 95 ± 20 (54-125) | 106 ± 16 (72-139) | <.001 |
| CMS relative to opposite side, % | 79 ± 16 (42-108) | 87 ± 9 (58-102) | <.001 |
| DASH score* (0 = no disability, 100 = maximum disability) | 29 ± 20 (1-66) | 30 ± 21 (1-68) | .246             |

CMS, Constant-Murley Score; DASH, Disabilities of the Arm, Shoulder and Hand Outcome Measure.
* Data are given as mean ± standard deviation (range).
Table II  Pain medication according to the World Health Organization grading

<table>
<thead>
<tr>
<th>WHO grade</th>
<th>Before trauma (n = 32)</th>
<th>6-month follow-up (n = 32)</th>
<th>1-year follow-up (n = 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>27 (84)</td>
<td>24 (75)</td>
<td>26 (81)</td>
</tr>
<tr>
<td>Level I</td>
<td>3 (9)</td>
<td>5 (16)</td>
<td>4 (13)</td>
</tr>
<tr>
<td>Level II</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Level III</td>
<td>2 (6)</td>
<td>2 (6)</td>
<td>2 (6)</td>
</tr>
</tbody>
</table>

WHO. World Health Organization.

Level of independency and quality of life

The social situation regarding independency before trauma and at follow-up after 6 and 12 months is reported in Table IV. At the 6-month follow-up, 84% of our cohort had reached their previous lifestyle. Five patients (16%) depended on an increased level of support compared with their situation before the trauma. After 12 months, 91% of our study group were back at their previous level of independency, but 3 patients (9%) required increased support. No patient had to give up life at home. The SF-36 score, including its subscores, showed no significant change over time (Table IV). Subjective outcome at 12 months was rated excellent by 22 patients (69%) and good by 10 patients (31%).

Discussion

Primary RSA for complex fractures of the proximal humerus in our elderly study group was associated with a low complication rate and only minor impairment regarding shoulder function compared with the uninjured contralateral side at 1 year of follow-up (87%). The level of independency and quality of life could be maintained in most of our patients.

Complications

By using the Nationwide Inpatient Sample database for 2011, Schairer et al. analyzed 7714 patients who received RSA (27.4%) or HA (72.6%) for treatment of a proximal humeral fracture. Overall, in-hospital complication rates were similar in both groups: systemic complications occurred in 1.85% and 2.21%, respectively, and local complications in 2.73% and 1.66%, respectively. These complication rates are much lower than reported in other studies. However, only in-hospital complications were provided. No revision surgery was performed in our cohort; however in 3 patients (9%), a crack of the proximal humerus metaphysis, which occurred during progressive reaming, had to be secured with a cerclage before the stem was finally placed.

Functional outcome

Our clinical results are similar to other series published in the current literature. Dezfuli et al. reported a CMS of 70 in elderly patients with a follow-up of 34 months after primary RSA. Klein et al. achieved a similar CMS of 68, although the tuberosities were excised in all patients. Age may influence the outcome significantly. Lopiz et al. showed that the CMS was significantly lower in patients aged ≥80 years compared with a younger group aged 75 to 79 years.

Although most authors found favorable clinical outcomes of RSA compared with HA in the most recent literature, this observation is not uniform. In a blind, randomized controlled prospective study from 2014, RSA was compared with HA for proximal humeral fractures in patients aged ≥70 years.
with a minimum follow-up of 2 years.29 The CMS (56 vs. 40) and all its subscores were significantly better for RSA, and only internal rotation was similar to HA. Other researches did not report any advantages of RSA.26,32 In the most comprehensive review article so far, Borson et al3 analyzed 18 studies containing 430 RSAs in acute fractures. The median CMS was 53 (range, 44–68) for RSA. They concluded that the functional outcome of RSA is not clearly superior compared with HA.

The main disadvantage of HA is its dependence on tuberosity healing for a good clinical outcome.31 In contrast, acceptable to good clinical results can be achieved with RSA even when the tuberosities are resected. Gallénet et al11 reported a series of 16 patients with RSA. In only 1 patient the tuberosities were reinserted, in all the others, the tuberosities and cuff were removed. After a mean follow-up of 1 year, the CMS was 53 and the DASH was 37. We found no correlation between functional outcome and tuberosity healing.

Of interest, the intraoperative assessment of the rotator cuff revealed a complete tear of the supraspinatus tendon in more than one-third of our patients. Some of the lesions may be attributed to a degenerative origin, others might exclusively—or at least partly—be caused by the recent shoulder trauma. However, one could hypothesize that this sub-group benefited the most from RSA because it is well known that these patients are expected to have poor shoulder function after osteosynthesis or HA even in the presence of osseous consolidation.12,15

**Pain**

Pain control is one of the most important outcome measurements after trauma. RSA usually provides excellent pain control.4,11,24 However, the results for conventional HA are similar without any clear advantage for one above the other.20 The current study assessed pain as part of the CMS and by an analysis of the patients’ analgesia medication, which was rated according to the official WHO grading.37 Pain control was excellent after 1 year, with all but 1 patient remaining in the same WHO level they had been before the injury.

**Radiologic outcome**

A recent meta-analysis35 revealed a better rate of healed tuberosity in the RSA patients compared with HA (84% vs. 47%). Tuberosity healing may be better for RSA because less force is transmitted to the greater tuberosity as a result of altered biomechanics. This may provide a more favorable environment for healing compared with HA.30 In our study group, a total resorption of the greater and the lesser tuberosity was observed in 19%.

The clinical significance of scapular notching remains unclear. It seems to increase with time. Cazeneuve and Cristofari4 reported a rate of 57% after a mean follow-up of 86 months. A systematic review3 reported scapular notching was evident with a median of 25%. In our series, scapular notching was seen in 38%, all being grade I or II. However, compared with other studies, our follow-up was only 1 year and an increased rate has to be expected over time.

**Level of independency and quality of life**

Many studies have mainly investigated functional outcome of RSA, but only a few have addressed its social implications for the affected individual such as loss of independency and institutionalization.7,9,24 In particular for elderly patients, the importance of functional outcome may be of inferior importance compared with the effect on the level of independency. Furthermore, a decrease of independency may be associated with increased long-term costs to finance professional care. In a retrospective German study,2 the ability of daily living management was analyzed in 52 patients with isolated proximal fractures of the humerus unrelated to different treatment patterns. At 4 months after trauma, 17% had to give up their own housekeeping, living subsequently in a retirement home. These patients were not monitored longer;
However, the authors assumed the number would further rise with time and emphasized the socioeconomic effect of these injuries. Merschin and Stang24 reported a very good preservation of independency similar to our observations. Only 3% of their study group had to be permanently institutionalized after RSA. However, 85% of geriatric patients who underwent HA for complex proximal fractures of the humerus were still able to live by themselves in their original environment despite a distinctly lower CMS compared with the uninjured side (41 vs. 77).8

The outcome of the SF-36 score and its mental and physical subscores in our study were similar to the normative data of the German population aged >75 years.10 Obviously, the subjective impairment of the shoulder as expressed in a DASH score of 30 had no negative effect on the quality of life (SF-36). Despite an improved objective shoulder function, we did not see a corresponding increase of the SF-36 values between the follow-up at 6 months and after 12 months. This observation is supported by the findings of other study groups that found no clear correlation between shoulder function and quality of life in elderly patients after different treatment modalities for proximal fractures of the humerus.25,26 Comparing the outcome of HA and osteosynthesis for Neer VI fractures, Spross et al27 found no difference between subgroups regarding the SF-36 score despite significant differences of shoulder function.33 They concluded that shoulder function impairment after a complex fracture of the proximal humerus had little effect on the quality of life in elderly patients.

The decision to perform RSA or conventional HA may be made on an individual basis focusing on the particular needs of the patient regarding shoulder function. RSA may be considered for active elderly individuals with a high demand on shoulder function, whereas HA may still be a good choice for a less active, institutionalized elderly patient with lower demands.

Limitations

The number of our patients is rather low, but there are no data available in the literature regarding the minimal clinically important difference for the overall CMS for patients undergoing RSA for complex fractures of the proximal humerus. For rotator cuff repair, values of 10.4 and 15 points have been determined to be significant.14,20 Based on an even smaller difference in our study group with an estimated drop-out of 10% after 1 year with a 2-sided significance of 0.05 and a power of 0.8, 30 patients would be required. Furthermore, follow-up is rather short compared with other investigations.11,18,22,24,29 However, because we focused on the effect of RSA on early restoration of function and its effect on the preservation of an independent life style, long-term results were beyond the scope of this study. There is no true control group with which outcome measures could be compared, and the shoulder function before the trauma is not known.

We only included patients with a high level of independency because we thought that independent and active patients would benefit most from good restoration of shoulder function. In contrast, the main focus in patients with lower demand may be rather pain control than function. By applying the above-mentioned inclusion criteria, we have certainly produced a selection bias. This bias must be considered when our results are compared with the results of other studies with different inclusion criteria.

Although the level of independency and the need for long-term support, ranging from professional home care to nursing homes, were among the main outcome parameters in this study, their effect on the socioeconomic consequences and overall costs was not investigated.

Conclusions

Primary RSA provides good early functional results, reliable pain control, and excellent restoration of an independent life style in elderly patients. Thus, it may be considered for active patients with a high demand on shoulder function.

Disclaimer

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References