Originalarbeit

Obere Extremität 2020 · 15:35–41
https://doi.org/10.1007/s11678-020-00559-z
Received: 5 December 2019
Accepted: 15 January 2020
Published online: 14 February 2020

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Outcomes and revision rates of primary vs. secondary reverse total shoulder arthroplasty for proximal humeral fractures

Proximal humeral fractures (PHF) are common in daily clinical routine and many PHF can be treated non-operatively [1, 2]. Several surgical options exist for the treatment of displaced and comminuted PHF [1–4]. Owing to its complexity, the operative treatment of PHF remains a surgical challenge. Consequently, high complication rates have been reported, especially for humeral head-preserving fracture fixation in elderly patients [1–4, 10].

If surgery is the treatment of choice and it is not possible to achieve a stable reconstruction by internal fixation, primary fracture arthroplasty is indicated. Varus displaced four-part fractures in elderly patients, displaced multiple-part fractures with a small humeral head fragment, non-reducible head-split fractures, and depressed fractures with more than 40% joint involvement carry a high risk of ischemia and necrosis and primary fracture arthroplasty is usually recommended for these fracture types [5, 6]. The functional success of anatomic fracture arthroplasty is related to the correct ingrowth of the tuberosities [7, 8]. In the case of rotator cuff insufficiency or fatty degeneration of the muscles, reversed fracture arthroplasty is an alternative option [9, 10]. Because of tuberosity-related complications with anatomic hemiarthroplasty, primary reverse total shoulder arthroplasty (RSA) is increasingly recommended as a surgical treatment option for elderly patients with displaced PHF [9, 11].

Recent meta-analyses compared outcomes of hemiarthroplasty (HA) and RSA for fracture management and concluded that the RSA group outperformed the HA group, with a lower rate of complications and better clinical function [12–15, 25].

The most recent studies demonstrated pain relief and only moderate functional limitations after primary RSA [12, 14]. However, two major problems limit the use of RSA for the treatment of comminuted PHF: the high complication rate of up to 36% (10–36%) that has been reported [16–19], and the severe limitation in external rotation [9, 20].

The purpose of this study was to analyze clinical results from primary vs. secondary RSA for the treatment of complex PHF in elderly patients. We hypothesized lower complication rates and better functional outcomes for primary RSA compared with secondary RSA.

Methods

This IRB-approved retrospective study was conducted at a level-1 trauma center. Patients treated with primary or secondary RSA for displaced proximal humeral fractures between January 2010 and December 2013 ($n = 151$) were screened for inclusion. Per this study's exclusion criteria, patients with pathologic fracture, preoperative glenohumeral joint infection, preoperative neurologic lesion of the affected arm, known dementia or death before follow-up were excluded. A total of 68 patients with a minimum of 12 months' follow-up since the index surgery with implantation of the same type of RSA (Delta Xtend, Depuy-Synthes, Warsaw, IN, USA) were finally included.

Of the remaining 68 patients, follow-up was available for 51 patients (75%) at a mean of 18.2 months (range, 12.2–45.0 months); 37 patients were examined clinically and 14 patients by questionnaire with assessment of the same functional outcome protocol. There were 45 women and six men with a mean age of 73 years (range, 59–87 years) at the time of implantation. In 28 cases, arthroplasty was implanted primarily (**Fig. 1**), in 23 cases secondarily. The interval between the index surgery and the revision procedure was 14.0 months (1.6–45.0 months).

Secondary RSA was implanted for varying indications: failure of locked plating ($n = 9$; **Fig. 2**), decompensation of an anatomic hemiarthroplasty ($n = 9$; **Fig. 3**), or failure of locked nailing ($n = 5$). Prior to revision, humeral head necrosis was found in four patients and one patient had a stiff shoulder. A bone defect of the glenoid cavity due to screw perforation was observed in one case. Intraoperatively, there were positive tissue cultures for one patient; however, further revision was not needed.

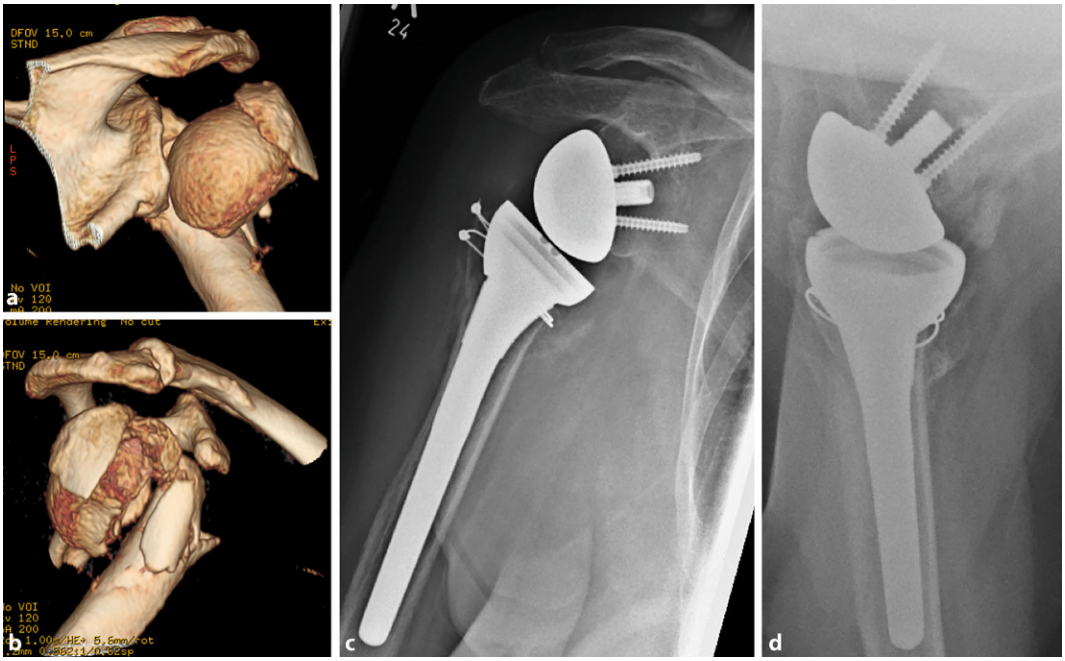

Fig. 1 ◀ A 74-year-old female patient: right shoulder with severely displaced type Resch 3GL proximal humeral fracture with metaphyseal comminution (**a**, **b**), treated with primary reverse total shoulder arthroplasty with refixation of the tuberosities using cable and cerclage wires (**c**, **d**)

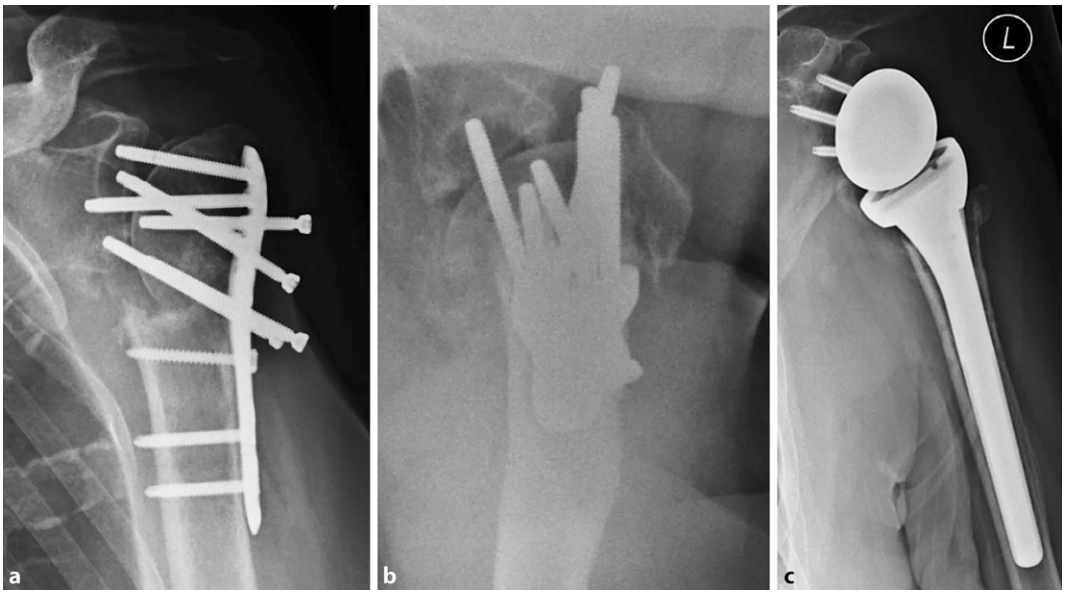

Fig. 2 ◀ An 89-year-old female patient: left shoulder with humeral head necrosis and collapse after locking plate fixation (**a**, **b**), treated with secondary reverse total shoulder arthroplasty (**c**)

Surgery was always performed under general anesthesia with the patient in beach-chair position. The deltopectoral approach was used in all cases. In terms of surgical techniques, there were two periods: From January 2010 to December 2011, no routine tuberosity refixation was performed. In 2012 and 2013, tuberosity refixation was performed routinely with cable cerclages. In the case of secondary arthroplasty, the decision of whether to reattach the tuberosities or not depended on their existence and bone quality.

Clinical and radiologic assessment

All patients ($n = 51$) were assessed according to joint active range of motion, DASH, Constant–Murley Score (CMS), Subjective Shoulder Value (SSV), and Visual Analog Scale (VAS) for pain. All patients with clinical examination ($n = 37$) underwent radiologic assessment after 12 months with shoulder X-rays in two planes (anteroposterior view and axillary view) to analyze tuberosity healing, heterotopic ossification, and inferior notching. Owing to the lack of consensus criteria in the literature for tuberosity consolidation in RSA, we considered an anatomic healing as visualization of the tuberosity in union with the humeral shaft [21]. The inferior notching of the scapula neck was graded according to the classification of Sirveaux et al. [22].

Statistical analysis

Data were organized in Excel (Version 14.5.4, Microsoft Corporation, Redmond, USA). Analyses were performed in SPSS (Version 21.0, IBM, Chicago, IL,

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Outcomes and revision rates of primary vs. secondary reverse total shoulder arthroplasty for proximal humeral fractures

Abstract

Background. Reverse total shoulder arthroplasty (RSA) is a standard treatment for proximal humeral fractures (PHF) and its sequelae. In this study we analyzed the clinical outcomes of primary vs. secondary RSA for displaced PHF in elderly patients.
Methods. We retrospectively reviewed 68 cases of primary or secondary RSA for displaced PHF. For 51 patients (28 primary RSA, 23 secondary RSA), a minimum 12-month follow-up with clinical and radiological assessment was available. Clinical assessment comprised joint active range of motion, DASH, Constant–Murley Score (CMS), Subjective Shoulder Value, and Visual Analog Scale for pain. Outcomes and complications of patients with primary RSA were compared with those of patients with secondary RSA.
Results. Follow-up data were available for 45 women and six men with a mean age of 73 years (range, 59–87) at the time of implantation. In 28 cases, primary RSA was performed; in 23 cases, RSA was performed as a revision procedure for fracture sequelae after failed plating, nailing, or hemiarthroplasty. The mean age- and gender-related CMS was 82.2 ± 34.2% (raw mean CMS: 46.8 ± 19.6 points). Among nine of the 51 patients with follow-up data (17.6%), ten complications occurred with six surgical revisions. Primary RSA ($n = 28$) resulted in better clinical shoulder function compared with secondary RSA ($n = 23$). Significantly more complications and revision surgeries were observed following secondary than primary RSA ($p = 0.013$).
Conclusion. In this study, primary RSA for displaced PHF in the elderly was associated with better clinical function and lower complication and revision rates than secondary RSA. Predictive parameters for failure of humeral head-preserving fracture fixation and anatomic hemiarthroplasty should be carefully evaluated. Primary RSA should be considered when surgical treatment of PHF is indicated in elderly patients.

Keywords

Humeral head fractures · Humeral head · Tuberosity refixation · Reverse arthroplasty · Plate fixation

Ergebnisse und Revisionsraten der primären vs. sekundären inversen Schulterendoprothese bei proximalen Humerusfrakturen

Zusammenfassung

Hintergrund. Die inverse Schulterendoprothesenversorgung (RSA) stellt eine Standardbehandlung für die proximale Humerusfraktur (PHF) und ihre Folgen dar. In der vorliegenden Studie analysierten die Autoren die klinischen Ergebnisse der primären vs. sekundären RSA bei einer dislozierten PHF älterer Patienten.
Methoden. Retrospektiv wurden 68 Fälle mit primärer oder sekundärer RSA bei dislozierter PHF ausgewertet. Bei 51 Patienten (28 mit primärer RSA, 23 mit sekundärer RSA) waren Daten über eine mindestens 12-monatige Follow-up-Phase mit klinischer und radiologischer Untersuchung verfügbar. Zur klinischen Untersuchung gehörten der Bewegungsumfang des Gelenks, DASH („disability of shoulder, arms and hand questionnaire"), Constant-Murley-Score (CMS), Subjective Shoulder Value und Visuelle Analogskala für Schmerz. Ergebnisse und Komplikationen der Patienten mit primärer RSA wurden mit denen der Patienten mit sekundärer RSA verglichen.
Ergebnisse. Für 45 Frauen und 6 Männer mit einem Durchschnittsalter von 73 Jahren (Spanne: 59–87) zum Zeitpunkt der Implantation gab es Follow-up-Daten. In 28 Fällen wurde eine primäre RSA durchgeführt; in 23 Fällen erfolgte die RSA als Revisionsoperation wegen Frakturfolgen nach fehlgeschlagener Plattenversorgung, Nagelung oder Hemiarthroplastik. Der durchschnittliche alters- und geschlechtsbezogene CMS betrug 82,2 ± 34,2 % (Rohdurchschnittswert des CMS: 46,8 ± 19,6 Punkte). Bei 9 der 51 Patienten mit Follow-up-Daten (17,6 %) kam es zu 10 Komplikationen mit 6 chirurgischen Revisionen. Die primäre RSA ($n = 28$) führten zu einer besseren klinischen Schulterfunktion als die sekundäre RSA ($n = 23$). Nach sekundärer RSA wurden signifikant mehr Komplikationen und Revisionseingriffe als nach primärer RSA festgestellt ($p = 0{,}013$).
Schlussfolgerung. In der vorliegenden Studie stand die primäre RSA bei dislozierter PHF älterer Patienten im Zusammenhang mit besserer klinischer Funktion und geringeren Komplikations- und Revisionsraten als die sekundäre RSA. Prädiktive Parameter für einen Misserfolg der den Humeruskopf erhaltenden Frakturfixation und der anatomischen Hemiarthroplastik sollten sorgfältig beurteilt werden. Wenn die chirurgische Behandlung einer PHF bei älteren Patienten indiziert ist, sollte die primäre RSA erwogen werden.

Schlüsselwörter

Proximale Humerusfraktur · Humeruskopf · Refixation der Tuberkula · Plattenosteosynthese · Inverse Prothese

USA). Normal distribution was determined by the Kolmogorov–Smirnov test. For comparison between groups, the unpaired Student *t* test, chi-square test, or nonparametric Mann–Whitney *U* test for continuous variables was used. A *p*-value of <0.05 was considered significant.

Results

The mean age- and gender-related CMS of all patients ($n = 51$) was 82.2 ± 34.2% (median 75.6%; raw CMS: mean 46.8 ± 19.6 points; range, 14–94 points, median 48 points). The active forward flexion averaged 106.1 ± 44° (range, 25–180°), the mean abduction was 100.2 ± 44.9° (range, 30–180), and the mean external rotation was 5.6 ± 7.8° (range, 0–40°). The overall SSV averaged 58.3 ± 22.2% (range, 10–95%), the mean DASH score was 41.2 ± 22.7 (range, 0–80.8), and VAS pain averaged 2.5 ± 2.3 (range, 0–7).

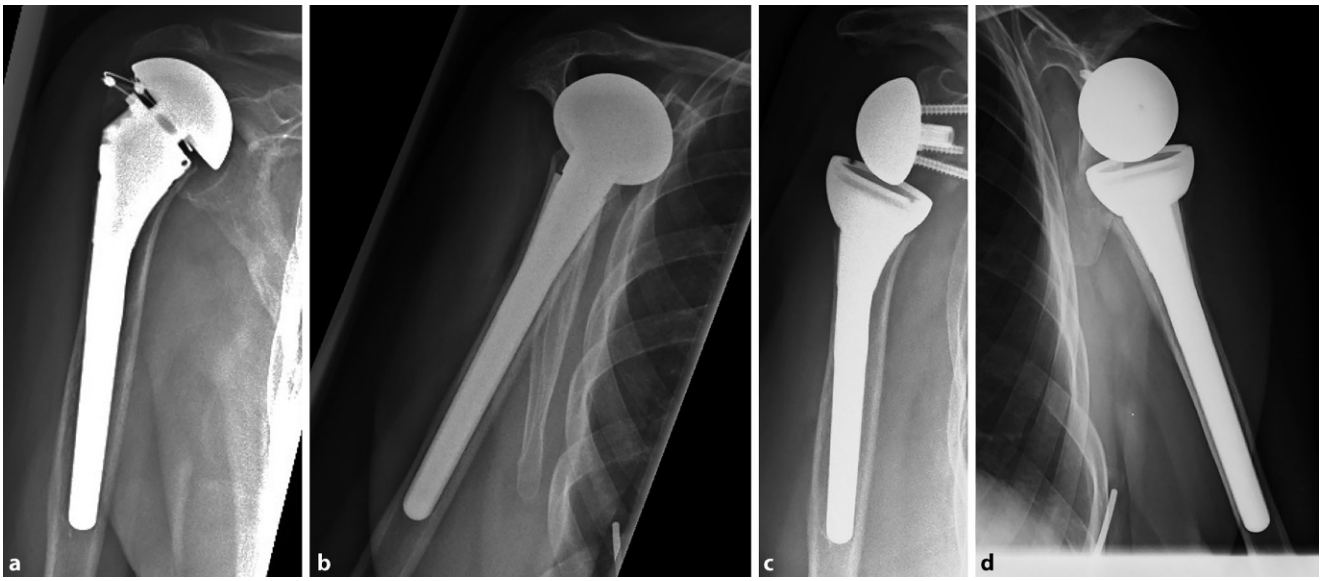

Fig. 3 ▲ A 72-year-old female patient: right shoulder with failure of hemiarthroplasty 6 months after implantation for a comminuted proximal humeral fracture (**a**, **b**) and secondary modular conversion to reverse total shoulder arthroplasty (**c**, **d**)

Radiographic results

The radiographic results of 37 patients demonstrated five prostheses (13.5%) with inferior notching of the scapular neck. On the basis of the Sirveaux classification [22], scapular notching was grade 1 in two patients and grade 2 in three patients. Heterotopic ossifications were found in 15 cases (40.5%). Tuberosity refixation had been performed in 14 of these 37 cases (37.8%), of whom two patients demonstrated anatomic consolidation (14.2%). The cable cerclage was broken in four of 14 cases (28.6%). In the other patients ($n = 8$), a resorption of the tuberosities was found (57.1%).

Ten complications occurred among nine of the 51 patients (17.6%) with follow-up data (**Table 1**). Prostheses that were implanted in the first years of our study period were affected by a higher complication rate (2010–2011: $n = 8/29$, 27.6%) than those that were implanted later (2012–2013: $n = 2/22$, 9.1%).

Primary vs. secondary arthroplasty

Overall, primary arthroplasty ($n = 28$) resulted in better clinical shoulder function compared with secondary arthroplasty ($n = 23$). We found a significantly better abduction, adduction, and forward flexion in patients with primary arthroplasty (**Table 2**). However, no significant difference was found between the external and internal rotation in primary and secondary RSA. Furthermore, we found no significant difference between the clinical outcome scores of primary and secondary RSA (**Table 3**).

More complications were observed after secondary (complication rate 8/23 = 34.8%) than after primary (complication rate 2/28 = 7.1%) RSA ($p = 0.013$). Furthermore, revision surgery had to be performed significantly more frequently following secondary (5/23 = 21.7% in 5 patients) than primary RSA (1/28 = 3.6% $p = 0.045$).

Discussion

The most important findings of this study were that primary RSA was associated with better clinical function and lower complication and revision rates than secondary RSA.

Several studies report on the functional results after primary RSA in PHF management. Klein et al. found a CMS of 67.9 in their study of 20 patients [11]. Bufquin et al. reported a CMS of 44 in their study of 43 patients [23], while in the study of Gallinet et al. comprising 19 patients the CMS was 53 [9].

Only few studies report on secondary RSA in fracture management. Cicak et al. found a CMS of 42 for 16 patients after failed open reduction and internal fixation (ORIF; [29]). In their study of 20 patients, Alentorn-Geli et al. reported a CMS of 26.6 [27], while Sebastia-Forcada et al. found a CMS of 22 after failed hemiarthroplasty in 6 patients [20].

In their study, Alentorn-Geli et al. compared secondary RSA ($n = 20$) with hemiarthroplasty ($n = 12$) for proximal humeral fracture sequelae after primary non-operative treatment [27]. The authors reported inferior functional results for secondary hemiarthroplasty with a gender- and age-related CMS of 26.6% after 39.6 months of follow-up. Dezfuli et al. compared results of RSA implanted as a revision procedure ($n = 12$ after failed hemiarthroplasty; $n = 11$ for failed fracture fixation; $n = 13$ after malunion or non-union) with primary RSA ($n = 13$; [28]). The authors found that primary RSA outperformed RSA as a revision procedure. The results of our study with larger groups of patients confirm their findings.

The complication rate of RSA for PHF is a major problem, with complication rates ranging from 0% [26, 27, 30, 31] to 68.4% [32].

Levy et al. reported a complication rate of 68.4% for secondary RSA [32]. Their results represent an early implantation period between 1999 and 2005.

Table 1 Complications and surgical revisions

Type of complication	*n* (%)	Primary RSA (*n* = 28)	Secondary RSA (*n* = 23)	Type of revision surgery
Dislocation	3 (5.9%)	1 (3.6%)	2 (8.7%)	Inlay replacement, *n* = 2 Closed reduction, *n* = 1
Fracture, periprosthetic	3 (5.9%)	0 (0%)	3 (13.0%)	Locked plating, *n* = 1 Non-operatively, *n* = 2
Hematoma with need for revision	2 (3.9%)	0 (0%)	2 (8.7%)	Debridement, *n* = 2
Deep wound infection	1 (2.0%)	1 (3.6%)	0 (0%)	Debridement and inlay replacement, *n* = 1
Neural injury	1 (2.4%) axillary nerve after revision	0 (0%)	1 (4.3%)	–

RSA reverse total shoulder arthroplasty

Table 2 Clinical function of the shoulder after primary vs. secondary arthroplasty

	Prosthesis	Patients (*n*)	Mean	SD	*p*
Abduction	Primary	28	116.3	47.2	0.004*
	Secondary	23	80.7	33.4	
Adduction	Primary	28	28.8	12.1	0.05*
	Secondary	23	19.3	10.5	
Forward flexion	Primary	28	122.9	46.3	0.002*
	Secondary	23	85.7	31.2	
Retroversion	Primary	28	24.6	11.2	0.631
	Secondary	23	23.0	12.4	
External rotation	Primary	28	6.1	9.4	0.630
	Secondary	23	5.0	5.4	
Internal rotation	Primary	28	34.8	15.6	0.186
	Secondary	23	41.3	18.9	

*$p < 0.05$ significant

Table 3 Clinical scores of patients after primary vs. secondary arthroplasty

	Prosthesis	Patients (*n*)	Mean	SD	*p*
CMS	Primary	28	89.7	37.2	0.083
	Secondary	23	73.1	28.4	
DASH Score	Primary	28	38.7	22.9	0.392
	Secondary	23	44.2	22.7	
SSV	Primary	28	62.8	21.6	0.112
	Secondary	23	52.8	22.1	
VAS	Primary	28	2.0	2.0	0.086
	Secondary	23	3.1	2.5	

CMS Constant–Murley Score, *DASH* Disabilities of the Arm, Shoulder and Hand, *SSV* Subjective Shoulder Value, *VAS* Visual Analog Scale
$p > 0.05$ = not significant

The complication rate may be reduced by senior surgeons [33, 34], and our results confirm this hypothesis of a learning curve. Prostheses that were implanted in the first year of our study period were linked toa higher complication rate (2010–2011: 27.6%) than those that were implanted later (2012–2013: 9.1%).

Recent studies report lower complication rates compared with earlier studies. Sebastia-Forcada et al. [20] found good results for pain reduction, clinical function, and revision rates in RSA for PHF with low complication rates (6.5%). Dezfuli et al. [28] reported a complication rate of 12%. In the literature, the most common complications are postoperative dislocations, nerve injuries, and infections. Farshad et al. [35] reported that dislocation with instability, hematoma, infection, and glenoidal complications were often an indication for revision surgery. The revision rate in the literature varies from 0% to 31.0% [32]. In our study, six surgical revisions were necessary (revision rate: 11.8%). Like Farshad et al., our revisions were indicated for postoperative dislocation, infection, hematoma, and periprosthetic fracture.

Several authors reported that RSA is favorable to ORIF or hemiarthroplasty for PHF in the elderly [5, 12, 13]. In view of the favorable outcomes of primary RSA versus RSA as a revision procedure for failed fracture fixation or failed hemiarthroplasty in the elderly, primary RSA should be considered when surgical treatment of PHF is indicated in elderly patients.

Limitations

The limitations of our study include the fact that it was non-randomized and retrospective with a minimum follow-up of 12 months. Further research is needed to better quantify the results and differences and especially the long-term results after RSA. The influence of scapular notching and deltoid muscle insufficiency, as seen in RSA for rotator cuff deficiency, may affect the long-term outcome.

Although our study is based on a larger sample size than other studies [9, 20, 21, 24, 28, 31, 32], it may be underpowered to

detect statistically significant differences for clinical outcome scores regarding primary versus secondary arthroplasty.

Practical conclusion

- **Primary reverse total shoulder arthroplasty (RSA) for displaced proximal humeral fractures (PHF) in the elderly is associated with better clinical function and lower complication and revision rates than secondary RSA.**
- **Predictive parameters for failure of humeral head-preserving fracture fixation and anatomic humeral head replacement should be carefully evaluated.**
- **When in doubt, primary RSA should be considered if surgical treatment of PHF is indicated in elderly patients.**

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Funding. Open Access funding provided by Projekt DEAL.

Compliance with ethical guidelines

Conflict of interest. J. C. Katthagen, E. Hesse, H. Lill, B. Schliemann, A. Ellwein, M.J. Raschke and J. Imrecke declare that they have no competing interests.

The study protocol was approved by the local ethics committee of the Medizinische Hochschule Hannover (1840–2013) and complied with the principles of the Declaration of Helsinki.

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