

Short to mid-term results of stemless reverse shoulder arthroplasty in a selected patient population compared to a matched control group with stem

Philipp Moroder^{1,2} · Lukas Ernstbrunner¹ · Christine Zweiger³ · Maximilian Schatz³ · Gerd Seidlinger⁴ · Robert Skursky⁵ · Johannes Becker¹ · Herbert Resch¹ · Rolf Michael Kriffter³

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Abstract

Purpose Little scientific evidence on the clinical and radiological outcome after stemless reverse shoulder arthroplasty (RSA) exists. The hypothesis of this study was that stemless RSA has an inferior outcome compared to RSA with stem.

Methods All cases of cuff-arthropathy fulfilling strict selection criteria (selection rate 18.4 %) were treated with stemless RSA between 2009 and 2013. Twenty nine of 37 cases (78.4 %) were clinically and radiologically examined by an independent observer. Twenty four of the 29 cases could be matched with 24 patients that underwent conventional stemmed RSA at a different institution based on the following criteria: indication (cuff-arthropathy), age (within 5 years), gender, and time of follow-up (within 2 years). Clinical and radiological outcomes of both groups were compared.

Results After mean follow-up of 35 months (range 24–75) no significant difference regarding constant score, ASES, subjective shoulder value, pain score, patient satisfaction, strength,

and range of motion was detected. One case of traumatic dislocation was observed in the stemless RSA group. Scapular notching grade 1 was detected in two cases of the stemless group while in the stemmed group five cases with grade 1 and four cases with grade 2 notching were observed. Average post-operative humeral component inclination (neck-shaft angle) in the stemless RSA group (134.4°) was significantly steeper than in the stemmed RSA group (155°) ($p < 0.001$). No loosening of the humeral component was observed in both groups.

Conclusion At short to mid-term follow-up, stemless RSA does not feature inferior clinical or radiological outcomes in a strictly selected patient population.

Keywords Inclination · Neck-shaft angle · Notching · Reverse shoulder arthroplasty · RSA · Stemless

Introduction

Complications related to the humeral stem in shoulder arthroplasty include intra-operative fractures, metaphyseal stress-shielding, and traumatic periprosthetic fractures [1–3]. Furthermore, extraction of humeral stems in the case of revision surgery can be challenging and associated with further complications [4]. Stemless shoulder arthroplasty might be able to alleviate the stem-associated complications, and showed promising early results regarding humeral component stability [5–11].

Stemless anatomical shoulder arthroplasty has been available for more than a decade and experienced an increase in variety of available systems and popularity among surgeons [12]. Stemless reverse shoulder arthroplasty (RSA), however, has yet to experience a breakthrough despite its availability for over ten years as well. Accordingly only a few outcome

✉ Philipp Moroder
philipp.moroder@pmu.ac.at

¹ Department of Traumatology and Sports Injuries, Paracelsus Medical University, Muellner Hauptstrasse 48, 5020 Salzburg, Austria

² Center for Musculoskeletal Surgery, Campus Virchow, Charité – Universitaetsmedizin, Augustenburger Platz 1, 13353 Berlin, Germany

³ Department of Orthopedic Surgery, Academic Teaching Hospital LKH Stolzalpe, Stolzalpe 38, 8852 Stolzalpe, Austria

⁴ Department of Orthopedic Surgery Oberndorf, Academic Teaching Hospital of the Paracelsus Medical University, Paracelsusstrasse 37, 5110 Oberndorf, Austria

⁵ Department of Radiology, LKH Judenburg-Knittelfeld, Oberweggasse 18, 8750 Judenburg, Austria

reports on stemless RSA can be found in the literature. While the published short to mid-term clinical and radiological outcomes seem to be promising all published case series lack an outcome assessment by an independent observer [13–16], except for one report regarding RSA with mini-stem [17].

The purpose of the current study was to provide an objective evaluation of the clinical and radiological short to mid-term outcome after stemless RSA. In order to do so a bi-centric case–control study with matched pairs and independent outcome assessment was conducted.

Methods

Study design and population

In this case–control study all patients with cuff-tear arthropathy that were treated with stemless RSA (TESS, Zimmer Biomet, Warsaw, IN, USA) between July 2009 and July 2013 at a single institution were included. In order to be eligible for the implantation of a stemless RSA the following strict selection process was applied: All patients with fracture or fracture sequelae, rheumatoid arthritis, malignoma, chemotherapy, renal insufficiency or previous shoulder arthroplasty were not deemed eligible for stemless RSA and thus were excluded. Intra-operatively, the following three selection criteria were assessed by the treating surgeon and had to be met, otherwise a RSA with stem was implanted: Intact cortical ring after performing the osteotomy, sufficient resistance of the trabeculae of the osteotomy side to pressure applied by the surgeon's thumb (thumb test), and no visible cysts at the osteotomy side. An independent observer (LE) from another shoulder centre was sent to the mentioned department and invited all patients with stemless RSA for clinical and radiological examination. The follow-up examination included constant score, ASES score, subjective shoulder value, satisfaction level, pain level, willingness to repeat surgery as well as ap and axillary radiography focused on the humeral component. Additionally, data regarding the duration of surgery, length of hospital stay, need for blood transfusion, post-operative complications, and revisions were collected. The examined patients were matched regarding indication (cuff-tear arthropathy), age (within 5 years), gender, and time of follow-up (within 2 years) with patients that had received a stemmed RSA (DELTA XTEND, DePuy Synthes, Warsaw, IN, USA) at another shoulder centre. These matched patients underwent the same clinical and radiological outcome assessment.

Local ethical committee approval was obtained prior to the beginning of this study (415-EP/73/299-2013).

Radiological assessment

The radiological assessment was performed by an independent observer (GS) according to the following-protocol:

The humerus was divided into four periprosthetic zones on the ap as well as on the axillary radiographs (Fig. 1). Each zone was assessed for radiolucencies and the presence of visible bone density loss. The inclination of the humeral component (neck-shaft angle, NSA) was measured on the ap-radiographs according to Teissier et al. [14] Inferior scapular notching was assessed according to Sirveaux et al. on ap-radiographies [18]. Additionally, humeral component subsidence was analyzed in both groups.

Statistics

Descriptive statistics including means, standard deviation, minimum and maximum values of the variables were calculated. The Kolmogorov-Smirnov test was employed to test all variables for normal distribution. Normally distributed variables were compared by means of the paired-samples student's T-test and non-normally distributed data using the Wilcoxon test. For comparison of categorical data the Fisher exact test was employed. To analyze correlations between parameters the Pearson's correlation coefficient was calculated. All *p*-values were 2-tailed and the alpha level was set to 0.05. Regarding clinical outcome in terms of the constant

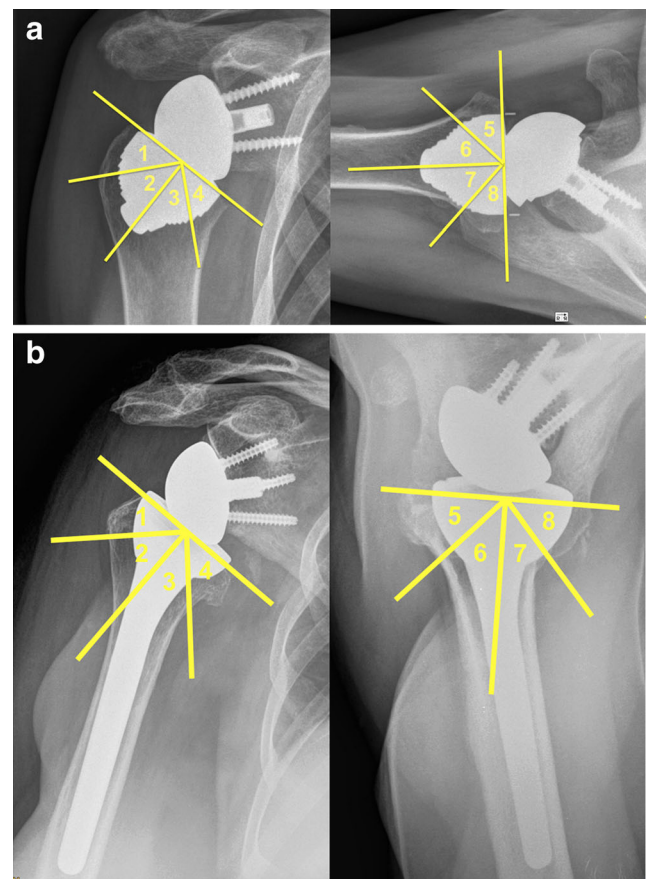


Fig. 1 For the assessment of radiolucencies and visible bone density loss the humerus was divided into four periprosthetic zones (each 45°) on the ap-radiographs as well as on the axillary radiographs

score the statistical power of the study was identified at approximately 75 % using a minimally clinically significant difference of 10.4 points [19].

Results

Demographics

Due to the strict selection process only 37 of 201 (18.4 %) patients treated for cuff-tear arthropathy at the mentioned department during the given time-interval were elected for stemless RSA. Eight of these patients were lost to follow-up. Six (16.2 %) had already died and two (5.4 %) were satisfied with the clinical outcome but declined the invitation for follow-up examination. Twenty four (82.8 %) of the remaining 29 patients could be successfully matched with patients that underwent stemmed RSA (Table 1).

Clinical outcome

No significant difference in constant score, ASES score, subjective shoulder value, pain level, as well as patient satisfaction was detected between the groups (Table 2). Regarding strength and range of motion also no significant differences were detected despite a statistical trend ($p = 0.055$) toward better internal rotation in the stemless RSA group (Table 2).

Post-operative complications in the stemless RSA group included one traumatic dislocation after a fall on a staircase two years after surgery (treated with inlay change and subscapularis tendon repair) (Fig. 2), one acromial spine fracture six weeks after surgery (conservatively treated), one symptomatic mesacromion (treated with tension-band osteosynthesis), and three cases of slight post-operative stiffness (treated conservatively). Complications in the stemmed RSA group included two post-operative haematomas (both treated with surgical evacuation), one transient paresthesia, and one case of inlay snapping (treated with inlay change).

The average time required for implantation was significantly shorter (80.5 vs 109.5 minutes) in the stemless RSA group ($p < 0.001$). The average hospital stay was significantly longer in the stemless RSA group (11.8 versus 7.9 days; $p = 0.006$).

Two of the patients receiving a RSA with stem required post-operative blood transfusions and none of the patients in the stemless RSA group ($p = 0.180$).

Radiological outcome

Radiolucencies or visible bone density loss was detected in one zone of one patient and four zones of two patients in the stemless RSA group (Fig. 3). In the stemmed group three patients showed radiolucencies or visible bone density loss in one zone and four patients in two zones. No overall radiological loosening of the humeral component or correlating clinical symptoms were observed in neither group.

Scapular notching grade 1 was detected in two cases of the stemless RSA group. In the group with stem five cases with grade 1 and four cases with grade 2 notching were observed.

The humeral component inclination in the stemless RSA group was 134.4° NSA (range 116° – 152°) which was significantly steeper than the 155° in the RSA group with stem ($p < 0.001$). In the stemless RSA group no significant correlation was found between the degree of humeral component inclination and the constant score, ASES score, SSV, flexion, abduction, external and internal rotation. The abduction strength showed a weak positive correlation with higher angle measurements ($R = 0.397$), however, statistical significance was not reached ($p = 0.055$).

Discussion

The goal of the study was to provide objective clinical and radiological outcome data for stemless RSA in comparison to conventional stemmed RSA. In order to improve comparability, a case–control study with patients matched in terms of indication, age, gender, and time of follow-up was completed. The patient cohort receiving a stemless RSA instead of conventional RSA underwent a strict selection process with clear inclusion and exclusion criteria meaning that all reported data on stemless RSA refer to a positive selection of patients which likely does not reflect the general population undergoing RSA.

According to our data, the clinical and radiological outcome of stemless RSA in a selected patient population is not

Table 1 Comparison of the two groups regarding the applied matching criteria

	Stemless reverse shoulder arthroplasty	Reverse shoulder arthroplasty	<i>p</i>
Indication: cuff-tear arthropathy	24/24 (Grade according to the Hamada classification 1: zero, 2: five, 3: eight, 4: seven, 5: four cases)	24/24 (Grade according to the Hamada classification 1: zero, 2: nine, 3: five, 4: four, 5: six cases)	1.000
Age (yrs)	75.6 ± 4.6	74.3 ± 4.6	0.062
Gender	17f 7 m	17f 7 m	1.000
Follow-up (months)	34.2 ± 10.5	35.2 ± 14.6	0.922

Table 2 Comparison of the clinical outcome

	Stemless reverse shoulder arthroplasty	Reverse shoulder arthroplasty	<i>p</i>
Constant score	65.4 ± 12.9	64.6 ± 16.0	0.859
ASES score	76.2 ± 10.8	78.0 ± 18.0	0.558
Subjective shoulder value	86.6 ± 11.9	82.5 ± 11.5	0.281
Pain (VAS)	0.4 ± 0.7	1.2 ± 2.0	0.181
Satisfaction (1–4)	1.1 ± 0.3	1.4 ± 0.6	0.052
Abduction strength (pts)	9.5 ± 4.1	11.1 ± 4.5	0.182
Flexion (pts)	7.8 ± 1.9	7.0 ± 2.1	0.192
Abduction (pts)	6.9 ± 2.0	6.8 ± 2.3	0.722
Internal rotation (pts)	5.3 ± 2.3	4.2 ± 2.4	0.055
External rotation (pts)	6.6 ± 2.6	7.3 ± 2.7	0.481

inferior to conventional RSA. The most apparent difference noted in the stemless RSA patients was the high variation regarding humeral component inclination. Many current stemmed RSA systems allow free choice of retroversion and posterior offset but only few new systems offer a changeable humeral component inclination. The lack of a stem allows free placement of the humeral component in all planes which on the one hand creates a great opportunity for the surgeon to freely choose a combination of retroversion, offset, and inclination, but on the other hand represents a challenge to the surgeons technical skills to obtain the desired positioning. Accordingly, the most common complication reported in previous studies of the same stemless RSA implant was early humeral component break-out (0 %, 2 %, 2 %, and 13 %)

not only attributed to poor bone quality but also implantation mistakes [13–16]. In our series with strict selection criteria (selection rate <20 %) no early or late humeral component break-out occurred.

The average inclination angle of the humeral component (NSA) in the reported stemless RSA group was approximately 135° and therefore significantly steeper than the fixed 155° of the stemmed Grammont-design RSA which results in an increased lateralization of the humerus [20]. This lateralization might improve the patients' ability to rotate the arm by recruiting more deltoid muscle fibers for rotational movements instead of abduction [21]. In our study no statistically significant difference in abduction strength or rotational motion was detected, however, a trend toward better internal rotation in

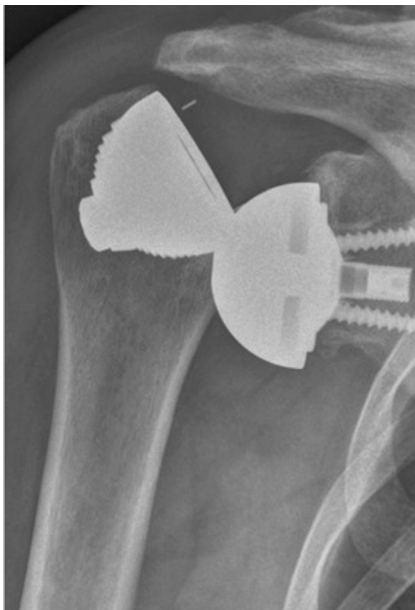


Fig. 2 AP-radiograph of a patient with post-traumatic dislocation of the stemless RSA after a fall on a staircase two years after surgery. The patient was successfully treated by changing the polyethylene cup to a higher liner as well as additional subscapularis reinsertion

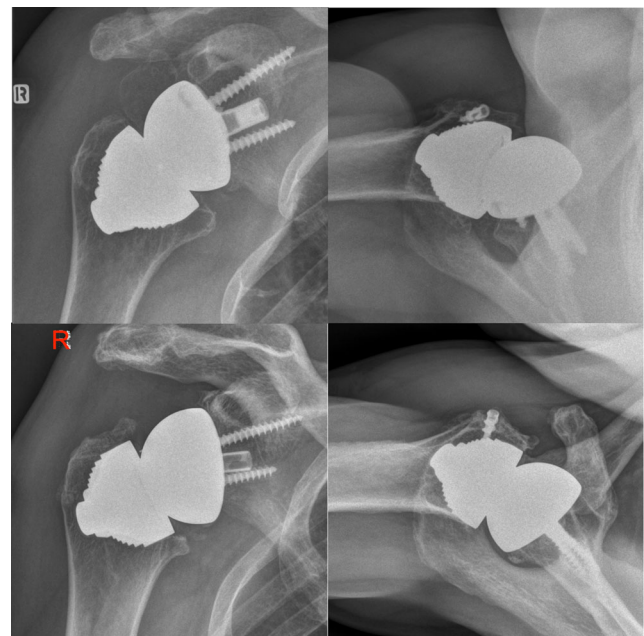


Fig. 3 AP and axial radiographs of two patients with stemless RSA showing radiolucencies or bone density loss in half of the periprosthetic zones without any clear radiological sign or clinical correlate of general humeral component loosening

the stemless RSA was noted. The steeper inclination angle of the humeral component is likely also the explanation of the lower notching rate in the stemless RSA group. A steeper humeral inclination might not only improve rotation and reduce notching but also convey the risk for subacromial impingement and reduced abduction capacity [20], however, the results did not show any according clinical or radiological correlates. A further concern with steeper humeral component inclination is instability [21] even if little evidence on the subject exists and the contribution of soft-tissue is unresolved. In our series one patient (132° humeral component) presented with a post-traumatic dislocation which was successfully treated with a higher liner and subscapularis reinsertion. This instability rate (4 %) is comparable with rates of previous reports for stemless RSA (0 %, 1 %, 2 %, and 13 %) [13–16], as well as the traditional Grammont design (4 %) [22].

No general loosening of the humeral component was noted in both groups, which confirms previous findings [13–16]. While in the RSA group with stem 29 % of the cases showed radiolucencies or visible bone density loss in one or two of eight zones, in none of the cases more than two zones were affected. All bony changes were observed in the metaphyseal area and are likely attributable to metaphyseal stress shielding or potentially to polyethilen-debris induced proximal humeral bone loss [3]. In two patients of the stemless RSA group radiolucencies or bone density loss was detected in four of eight zones without any clear radiological sign or clinical correlate of general component loosening (Fig. 3).

Regarding general complications recorded in both groups no distinct differences were noted which could be attributed to the lack of a stem. In the stemless group the implantation time was significantly shorter (by approx. 30 minutes), while the average hospital stay was significantly longer (by approx. 4 days). Both parameters are, however, subject to local hospital circumstances.

Limitations

A limitation of this study is the different prosthesis type used and possibility of technical differences between both centres. In both centres all surgeries were executed or supervised by an experienced shoulder surgeon with similar surgical technique including the use of the delto-pectoral approach, the reinsertion of the subscapularis tendon whenever possible, placement of the humeral component in 20° of retroversion, inferior placement of the metaglene with slight inferior tilt, use of two different glenosphere sizes depending on the patients' individual anatomy and size, as well as post-operative sling immobilization and limitation to passive motion exercises for three weeks followed by rehabilitation programs.

Even though patients were matched regarding their surgical indication (cuff-tear arthropathy), the lack of information on

the pre-operative status of the remaining rotator cuff in both groups is a limitation of this study.

A further limitation is the difficulty to clearly identify periprosthetic radiolucencies and bone density loss which often leave room for interpretation. However, an effort was made to have an independent observer perform the radiological analysis.

Finally, the sample size in both groups is rather small, however, an effort was made to define strict inclusion and exclusion criteria as well as matching criteria which improved the homogeneity and comparability as well as the statistical power of the study.

All five patients with stemless RSA that were examined but could not be matched and thus were not included in the group comparison were very satisfied with the outcome, did not undergo revision surgery, and did not experience any kind of post-operative complication.

Conclusions

At short to mid-term follow-up, stemless RSA did not feature inferior clinical outcomes in a strictly selected patient population. No humeral component loosening was observed at follow-up. The stemless RSA group showed a high variability in the degree of inclination of the humeral component with on average steeper positioning than the standard 155° NSA of the stemmed RSA group, thus favoring a smaller rate of scapular notching.

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Compliance with ethical standards

Conflict of interest Philipp Moroder: receives consulting fees from Arthrex, Inc.

Lukas Ernstbrunner: none

Christine Zweiger: none

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Robert Skursky: none

Gerd Seitlinger: receives consulting fees from Arthrex, Inc.

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Approval of the local ethical committee of Salzburg, Austria was obtained (415-EP/73/299-2013).

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