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Reverse shoulder arthroplasty in the treatment of glenohumeral instability

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Background: Glenohumeral instability is a rare indication for primary reverse total shoulder arthroplasty (RTSA), accounting for fewer than 1% of the indications in the literature. The aim of this study was to analyze the clinical and radiographic outcomes of RTSA for recurrent instability after failed operative repair or instability associated with major bone loss in elderly patients.

Methods: A retrospective matched case-control study was performed. We compared 11 shoulders treated with RTSA for instability (cases) with 22 matched shoulders treated with RTSA for rotator cuff insufficiency (controls). Clinical and radiographic outcomes were compared.

Results: The median follow-up period was 74 months (interquartile range [IQR], 18 months; range, 22-171 months) in cases and 70 months (IQR, 13 months; range, 23-172 months) in controls. The median age was 74 years (IQR, 18 years) in the case group and 70 years (IQR, 13 years) in the control group. No significant differences were found between the 2 groups in satisfaction scores, preoperative and postoperative absolute and relative Constant scores, and complication rates. Active range of motion tended to be superior in the controls for mean flexion (130° vs. 110°, $P = .15$), abduction (143° vs. 100°, $P = .16$), and external rotation (28° vs. 20°, $P = .86$) without the differences reaching statistical significance, possibly because of the small sample size. Postoperative dislocation was not recorded in cases or controls, but subjective insecurity regarding stability was reported once in each group.

Conclusion: RTSA seems to represent a valuable treatment option for glenohumeral instability in an elderly population with large bone loss or as a salvage procedure after failed operative glenohumeral stabilization. Postoperative instability was not observed in the case and control groups.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Reverse total shoulder arthroplasty; glenohumeral instability; chronic shoulder dislocation; rotator cuff arthropathy; glenoid bone loss; anterior instability; posterior instability

Chronic glenohumeral instability in elderly patients or after (multiple) failed stabilization procedures represents a surgical challenge. Improvements in the surgical technique and design of reverse total shoulder arthroplasty (RTSA) have led to the expansion of indications for this type of implant.[8,9,13,14,17,20] Compared with irreparable, massive cuff tearing, which is the most common indication for RTSA, glenohumeral instability is a very rare indication for this

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Table I Clinical outcomes of non-matched cases (n = 3), including Constant scores

	Case 1, aged 56 yr, left shoulder		Case 2, aged 34 yr, left shoulder		Case 3, aged 35 yr, right shoulder	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
Pain score	15	NA	4	10	8	10
Activity work score	3	NA	4	2	1	2
Activity sports score	4	NA	3	2	2	2
Activity sleep score	2	NA	0	2	2	2
Flexion, °	140	NA	90	65	100	65
Abduction, °	70	NA	90	70	140	70
External rotation, °	80	NA	30	15	20	15
Abduction power*	3.8	NA	3.3	NA	4.4	NA
SSV, %	NA	NA	NA	70	NA	70
aCS, %	67	NA	30	42	37	42
rCS, %	71.8	NA	32.3	44	39.4	44

NA, not available; *SSV*, Subjective Shoulder Value; *aCS*, absolute Constant score; *rCS*, relative Constant score.
The 3 cases (2 patients) that were not matched did not have postoperative complications. The patient, who underwent surgery on both sides, had uncontrollable instability but free active range of motion; she lost active range of motion but achieved freedom from pain and regained stability and was very happy with the objectively fair result.
* Mean value of 3 trials (kilograms × 2.19), corrected for age and sex.

treatment. According to the Australian registry of arthroplasty, instability represents 0.3% of the diagnoses for primary RTSA.[1] There is no general consensus regarding the treatment of instability in elderly patients and in patients with persistent instability after multiple failed conventional stabilization procedures. Prior to the advent of RTSA, persistent shoulder instability was treated with shoulder arthrodesis with limited functional outcomes.[11,18] A fusion could be achieved in 96% of patients with pain relief for three-quarters, but performing light work at shoulder level was just possible for 25% of patients.[2] To our knowledge, there are currently no data regarding the outcome of RTSA in the treatment of chronic, recurrent shoulder instability.

The aim of this study was to analyze the clinical and radiographic outcomes of RTSA for recurrent instability after failed operative repair or instability associated with major bone loss in elderly patients.

Materials and methods

This was a retrospective case-control study of the clinical and radiologic outcomes of RTSA for recurrent instability after failed operative repair or instability associated with major bone loss in elderly patients. Between 1999 and 2015, 424 primary RTSAs were performed in our institution. Most of these patients were treated for rotator cuff deficiency (n = 332, 78%). Fracture sequelae or acute fractures were present in 76 shoulders (18%). Treatment was performed for chronic recurrent instability in 16 shoulders (4%). For our study, chronic uncontrollable instability was defined as instability after failed instability treatments or in elderly patients with shoulder instability and large glenoid bone defects (due to fractures and fracture-dislocations), in whom another stabilization surgery was not considered an option. All patients had at least 1 traumatic dislocation of the shoulder. Patients with cranial migration of the humeral head (acromiohumeral distance < 7 mm[19]) were assigned to the rotator cuff arthropathy group. In this control group, recurrent instability was not present. If, in addition to RTSA, other surgical measures (eg, latissimus dorsi transfer) were taken, the case was excluded. Of the 16 patients, 2 had died unrelated to the RTSA operation. Fourteen patients were left for the initial analysis. Three cases could not be matched because of young age and were excluded from the demographic, radiographic, and clinical analyses (3 shoulders in 2 women; median age, 35 years) (as detailed in Table I). These 3 cases did not have postoperative complications. The second patient, who underwent surgery on both sides, had uncontrollable instability but free active range of motion; she lost active range of motion but achieved freedom from pain and regained stability and was very happy with the objectively fair result.

Finally, 11 shoulders in 11 patients (5 men and 6 women; median age, 74 years [IQR, 18 years]) treated with RTSA were available for analysis; 10 cases were treated for anterior instability, and 1 case was treated for posterior instability. These patients were matched with 22 shoulders in 22 patients treated with RTSA for rotator cuff insufficiency (9 men and 13 women; median age, 70 years [IQR, 13 years]). All patients gave written consent to participate in the study. Demographic parameters (age, sex, previous stabilization surgery, comorbidities, and presence of osteoarthritis) and surgery-related characteristics (implant type and use of cement for the humeral shaft) were evaluated.

Clinical and radiographic assessment

Clinical and radiographic examinations were performed preoperatively and approximately 1 year, 2 to 5 years, 5 to 8 years, 8 to 10 years, and more than 10 years postoperatively. The clinical examination included measurement of active and passive ranges of motion using a handheld goniometer and assessment of the absolute Constant score

(aCS),[4] relative Constant score (rCS),[3] and Subjective Shoulder Value (SSV).[7] Patients rated their overall postoperative satisfaction as excellent, good, fair, or disappointed. Abduction strength was measured with a validated electronic dynamometer (Isobex; Cursor, Bern, Switzerland).[5] Preoperatively and postoperatively, standardized true anteroposterior, axillary lateral, and scapular lateral radiographs were obtained for all patients. On anteroposterior radiographs, grades of rotator cuff arthropathy were identified according to the Hamada classification.[10] On preoperative computed tomography scans, glenoid dysplasia was graded according to the Walch classification[24] and Favard classification.[12] Outcome measurements evaluated on the postoperative radiographs were inferior scapular notching according to the Sirveaux classification,[21] radiolucency, glenoid or humeral loosening, and glenoid or acromial fracture.

Surgical technique

The surgical technique for RTSA was performed as described by Werner et al.[26] Because the standard implant used in the hospital has changed over time, 3 different implants were been used. The Delta III reverse shoulder prosthesis (DePuy Synthes, Warsaw, IN, USA) was implanted in 2 shoulders (18%) in the case group and 3 shoulders (14%) in the control group, whereas the Anatomical Shoulder Reverse prosthesis (Zimmer Biomet, Warsaw, IN, USA) was implanted in 8 shoulders (73%) in the case group and 19 shoulders (86%) in the control group. One Aequalis reverse prosthesis (Tornier, Edina, MN, USA), which is biomechanically identical to the Delta III prosthesis, was used in the case group. The humeral component was cemented in place with gentamicin-impregnated bone cement (Palacos; Heraeus Kulzer, South Bend, IN, USA) in 6 shoulders (55%) in the case group and 12 shoulders (55%) in the control group. If possible, the subscapularis tendon was reattached to the lesser tuberosity at the end of the procedure. The subscapularis tendon was repaired in 6 shoulders in the case group (54%) and 17 shoulders (77%) in the control group. If a type B2 or C glenoid was present, depending on the intraoperative site, the surgeon decided whether to perform autografting with the humeral head to correct the retroversion (2 cases) or undertake sparing asymmetrical reaming (2 cases).

Statistical analysis

Matching was performed in a 1:2 pattern of cases to controls for age (±10 years), sex, and follow-up period (±1 year). Data were mainly non–normally distributed, and medians and interquartile ranges (IQRs) are provided. The Wilcoxon rank sum test was used to compare measurements between groups. A conditional logistic regression model for the SSV was fitted to account for the potential confounders age, sex, and side to compare controls and cases. A post hoc power analysis revealed that the minimal detectable odds ratio would be 39 (if the risk of instability in the control group was 1%, the power was 0.8, matching was 1:2, and n = 11 for cases). The Stata/IC program (version 13.1; StataCorp, College Station, TX, USA) was used.

Results

Patients were examined at a median of 61 months (IQR, 91 months; range, 22-171 months) in the case group and 48 months (IQR, 60 months; range, 23-172 months) in the control group ($P = .39$). The dominant shoulder was involved in 7 cases (64%) and 13 controls (59%). Signs of osteoarthritis were present in 4 of 11 cases (36%) and 13 of 22 controls (59%) ($P = .22$).

In the case group, 3 cases (27%) underwent at least 1 stabilization surgical procedure before RTSA (2 Bankart procedures and 2 Latarjet procedures). In the control group, 7 patients underwent shoulder arthroscopy with rotator cuff repair or débridement before the index surgical procedure.

Preoperative bony degeneration and morphologic characteristics are displayed in Table II. A statistical difference was seen in glenoid morphology according to the Favard classification,[12] with significantly greater glenoid defects in the control group ($P = .030$). Preoperatively, we found 7 glenoid fractures with bone loss (64%) in the case group but only 1 (5%) in the control group ($P = .001$). A locked anterior static glenohumeral dislocation existed in 6 patients (55%) in the case group. Preoperatively, 1 acromial fracture was present in the control group.

After surgery, we recorded 2 complications (18%) in the case group and 2 (9%) in the control group ($P = .45$). In the case group, there was 1 acromial fracture (seen at 1 year of follow-up, treated conservatively) and 1 patient with persistent subjective instability 1 year after the index surgical procedure. With dynamic fluoroscopy, slight subluxation without dislocation of the components was observed, probably due to undertensioning of the deltoid, and a revision surgical procedure with an increase in the metaphyseal implant was performed (12 mm of humeral offset). After the revision operation, the patient still had ongoing pain and very limited shoulder function. No further surgical treatment was desired.

In the control group, 1 patient with a preoperative acromial fracture (after arthroscopic acromioplasty) became symptomatic after implantation of the prosthesis. Osteosynthesis and hardware removal were performed 1 year and 2 years after the index surgical procedure, respectively. The patient remained symptomatic for pain. Another patient in the control group had persisting pain and subjective instability after surgery. With the working diagnosis of a low-grade periprosthetic infection, the patient underwent arthroscopic débridement and collection of tissue samples. No bacteria were found. The symptoms remained; therefore, 6 months later, a revision surgical procedure was performed with an increase in the height of the metaphysis (by 6 mm). The patient remained symptomatic with a very low SSV of 20% at the last follow-up. Regardless of the poor outcome, we could not find any surgical treatment to substantively improve the patient's symptoms.

Clinical outcomes

Comparison between cases and controls

Postoperative satisfaction at the last follow-up was graded as excellent or good by 64% of cases (n = 7) and 90% of

Table II Exposure data (N = 33)

	Control (n = 22), n (%)	Case (n = 11), n (%)	*P* value*
Walch classification (n = 31)			.269
A1	13 (59)	9 (100)	
A2	4 (18)	0 (0)	
B1	1 (5)	0 (0)	
B2	3 (13)	0 (0)	
C	1 (5)		
Favard classification (n = 32)			.030†
E0	10 (45)	8 (80)	
E1	12 (55)	1 (10)	
E2	0 (0)	1 (10)	
E3	0 (0)	0 (0)	
Hamada classification (n = 22)			NA
1	12 (55)	NA	
2	4 (18)	NA	
3	4 (18)	NA	
4	0 (0)	NA	
5	2 (9)	NA	

NA, not applicable.
* χ^2 Test.
† Significant difference.

controls (n = 18) ($P > .999$). Complete results for satisfaction measurements are shown in Table III.

No statistically significant differences were found between the 2 groups in preoperative and postoperative aCS and rCS (as well as the difference in both). Concerning postoperative range of motion, the control group scored better in median flexion (130° [IQR, 40°] vs. 110° [IQR, 60°], $P = .15$), abduction (143° [IQR, 70°] vs. 100° [IQR, 70°], $P = .16$), and external rotation (28° [IQR, 40°] vs. 20° [IQR, 20°], $P = .86$). Similar findings were noted for the rCS, which showed values of 84% (IQR, 22%) in the controls and 64% (IQR, 40%) in the cases ($P = .42$). Complete results for the Constant score are shown in Table IV.

The differences in the results remained nonsignificant ($P = .773$) for the SSV even when fitting a conditional regression model adjusting for age, sex, and follow-up. The mean SSV and rCS were not significantly different between cases with 1 dislocation and those with more than 1 dislocation (SSV of 60% [IQR, 90%] vs. 25% [IQR, 29%], $P = .604$, and rCS of 42% [IQR, 44%] vs. 25% [IQR, 63%], $P = .796$).

Preoperative and postoperative results of case group

The clinical outcomes of the case group improved significantly after RTSA. The median score for pain changed from 6 preoperatively to 15 postoperatively ($P = .007$). The median activity work score changed from 1 preoperatively to 4 postoperatively ($P = .007$). The median activity sport score changed from 1 preoperatively to 3 postoperatively ($P = .044$). The median SSV changed from 20% preoperatively to 80% postoperatively ($P = .037$). The median aCS increased from 25 to 53 ($P = .009$). The complete categorical and continuous preoperative and postoperative clinical outcome parameters in the case group are reported in the Tables V and VI, respectively.

Radiographic outcomes

The results of the Sirveaux notching classification[21] of the 2 groups are reported in Table VII. No statistical difference was seen. At latest follow-up, no stem or glenoid loosening was observed in any of the shoulders.

Discussion

The indication for RTSA is decisive for the success of the procedure. With the increase in life expectancy, elderly patients with glenohumeral instability are no more a rarity. Whether RTSA is a valuable treatment for chronic instability is not yet determined in the literature.

Although not significantly different, the mean preoperative function of the shoulders with recurrent instability was inferior to that of shoulders with rotator cuff insufficiency, indicating major disability caused by this condition and the need for treatment. With a rate of 4% in our study, the condition was found at more than 10-fold the rate in the Australian joint registry mainly because of the specific referral pattern of our department. Nonetheless, the cohort size was very small, so the better clinical and radiographic outcomes and the lower complication rate in the control

Table III Preoperative and postoperative satisfaction measurements (n = 31)

	Preoperative			Postoperative		
	Control (n = 14), n (%)	Case (n = 6), n (%)	*P* value*	Control (n = 20), n (%)	Case (n = 11), n (%)	*P* value*
Satisfaction			.268			>.999
Disappointed	6 (43)	3 (50)		2 (10)	1 (9)	
Fair	7 (50)	1 (17)		0 (0)	3 (27)	
Good	0 (0)	1 (17)		4 (20)	1 (9)	
Excellent	1 (7)	1 (17)		14 (70)	6 (55)	

* χ^2 Test.

Table IV Continuous outcome data (N = 33)

	Preoperative			Postoperative			Difference		
	Control (n = 22), median (IQR)	Case (n = 11), median (IQR)	*P* value*	Control (n = 22), median (IQR)	Case (n = 11), median (IQR)	*P* value*	Control (n = 22), median (IQR)	Case (n = 11), median (IQR)	*P* value*
Pain score (CS)	5 (7)	6 (10)	.363	15 (2)	15 (5)	.729	6 (8)	4 (7)	.204
Activity work score	1 (2)	1 (2)	.401	4 (1)	4 (2)	.338	2 (2)	2 (4)	.907
Activity sports score	1 (2)	1 (2)	.353	4 (1)	3 (2)	.143	2 (2)	2 (4)	.816
Activity sleep score	1 (1)	1 (2)	.361	2 (0)	2 (0)	.759	1 (2)	1 (1)	.345
Flexion, °	95 (70)	80 (110)	.275	130 (40)	110 (60)	.150	33 (65)	20 (65)	.863
Abduction, °	70 (90)	60 (50)	.804	143 (65)	100 (70)	.162	33 (100)	20 (60)	.400
External rotation, °	30 (25)	25 (35)	.432	28 (40)	20 (15)	.863	−5 (30)	0 (40)	.199
Abduction power†	2.7 (5.9)	0 (5.2)	.485	8.7 (13.8)	3.9 (13.1)	.373	5.0 (9.1)	0 (11.8)	.527
SSV, %	30 (30)	20 (70)	.493	80 (20)	80 (61)	.495	50 (40)	25 (90)	.368
aCS, %	35 (22)	25 (31)	.276	70 (17)	53 (28)	.221	27 (26)	22 (38)	.702
rCS, %	52 (24)	39 (56)	.834	84 (22)	64 (40)	.423	26 (26)	25 (57)	.819

IQR, interquartile range; *SSV*, Subjective Shoulder Value; *aCS*, absolute Constant score; *rCS*, relative Constant score.

* Wilcoxon rank sum test.

† Mean value of 3 trials (kilograms × 2.19), corrected for age and sex.

group did not reach statistical significance. However, the data are suggestive that uncontrollable instability may be associated with worse results than in patients treated for a massive rotator cuff tear. Nevertheless, patients with this rare pathology seemed to benefit greatly from the procedure, and their shoulders remained stable. In addition, they significantly improved in terms of pain, daily activity, activity work, activity sports, and activity sleep scores, and their SSV and aCS were significantly better than preoperatively.

A median improvement in flexion and abduction of 30° and 40°, respectively, as well as an improvement of the rCS by 25%, was seen. The preoperative to postoperative differences between the 2 groups were thus very similar.

The superiority of RTSA compared with anatomic implants was reported by Statz et al in 2017 for locked anterior shoulder dislocation.[22] In our study, postoperative dislocation was not recorded in cases or controls, but subjective insecurity regarding stability was reported in 1 case in each group and required revision to a higher metaphyseal liner.

Probably owing to the characteristics of the higher constrained implants used, no particular modification of the technique was required. In each group, there was 1 case of remaining subjective instability that did not improve after a humeral offset increase and that was not associated with objective dislocation.

To our knowledge, our study is the only one considering a group of elderly patients with glenohumeral instability or failed stabilization treatment and treating the condition with RTSA. A similar study from Kurowicki et al[16] focused on RTSA in the treatment of locked anterior shoulders. They compared 24 cases of locked glenohumeral dislocations with a population of 48 shoulders treated with reverse shoulder arthroplasty for conventional indications. The control group showed better results for most of the clinical values (American Shoulder and Elbow Surgeons, Simple Shoulder Test, and visual analog scale scores), as well as significantly better range of motion in active forward flexion and abduction. The rate of postoperative acromial stress fractures was significantly higher in the case group, with 21% vs. 9% in the control group.

Table V Categorical preoperative and postoperative clinical outcome parameters in case group

	Preoperative, n (%)	Postoperative, n (%)	*P* value*
Liftoff	4	8	>.999
Positive	1 (25)	7 (88)	
Negative	3 (75)	1 (12)	
Satisfaction	6	11	.50
Low or moderate	4 (67)	4 (36)	
High or very high	2 (33)	7 (63)	

* χ^2 Test.

Table VI Continuous preoperative and postoperative clinical outcome parameters in case group (n = 11)

	Preoperative, median (IQR)	Postoperative, median (IQR)	*P* value*
Pain score	6 (10)	15 (5)	.007
Activity work score	1 (2)	4 (2)	.007
Activity sports score	1 (2)	3 (2)	.044
Activity sleep score	1 (2)	2 (0)	.052
Flexion, °	80 (110)	110 (60)	.100
Abduction, °	60 (50)	100 (70)	.194
External rotation, °	25 (35)	20 (15)	.929
Abduction power†	0 (5.2)	3.9 (13.1)	.241
SSV, %	20 (70)	80 (61)	.037
aCS, %	25 (31)	53 (28)	.009
rCS, %	39 (56)	64 (40)	.131

IQR, interquartile range; *SSV*, Subjective Shoulder Value; *aCS*, absolute Constant score; *rCS*, relative Constant score.
* Wilcoxon signed rank test.
† Mean value of 3 trials (kilograms × 2.19), corrected for age and sex.

Table VII Sirveaux notching classification[21] results (N = 33)

	Control (n = 22), n (%)	Case (n = 11), n (%)	*P* value*
Notching classification			.198
0	9 (41)	3 (27)	
1	5 (23)	4 (36)	
2	0 (0)	2 (18)	
3	6 (27)	1 (9)	
4	2 (9)	1 (9)	

* χ^2 Test.

Moreover, 2 cases showed persistent instability after the operation. The differences from our results can perhaps be explained by our small study group with an underpowered cohort and the invariably locked dislocations as opposed to our study, in which only 6 of 11 dislocations were locked.

An alternative to RTSA in elderly patients is the Trillat procedure.[6,23] According to Walch et al,[25] this procedure can be used for recurrent dislocation in patients older than 40 years with additional rotator cuff injuries. Of their patients, 70% had osteoarthritic shoulders and 50% had superior migration of the humeral head. The treatment consisted of coracoid osteotomy as described by Trillat et al.[23] The results were objectively good in 63% and the patients were satisfied in 88% of the cases. This study differs from ours because the mean age of their patients was lower and the patients had concomitant rotator cuff insufficiency. In addition, the Trillat procedure was performed in patients with non-pseudoparalytic shoulders and good overhead function. Jouve et al performed a

similar study of concurrent instability and rotator cuff tear treatment.[15] They examined 28 shoulders in their study.[15] An open Trillat procedure was performed in 19 cases (mean age, 59.3 years) in which the cuff was not reparable or the patient refused the repair, whereas the Latarjet procedure with rotator cuff repair was performed in 9 cases (mean age, 40 years). After a mean follow-up period of 73.5 months, the mean Constant score improved from 63 to 78 points ($P < .05$). In the Trillat group, there was an instability recurrence rate of 16%. In contrast, no patients had a recurrence after the Latarjet procedure and rotator cuff repair. Of the patients, 96% were satisfied. Osteoarthritis progressed in 64%.[15] In our patient group, multiple conventional stabilization procedures had already failed or the glenoid defect or osteoarthritis changes were considered too severe to proceed with joint-preserving procedure. Moreover, our preoperative Constant score of 25 points shows clearly that our patients differed from those of Walch et al, who had a mean preoperative Constant score of 63 points.

The strength of our work is the selection of patients with strict inclusion criteria. Patients with anterosuperior instability because of an insufficient rotator cuff were excluded.

The main limitation of this study is the number of patients owing to the rarity of the condition even in a large referral practice. Despite the sample size, we believe that in the absence of documentation of this entity in the literature, the fact that patients benefit substantially and their shoulders remain stable is a valuable addition to our knowledge.

Conclusion

'RTSA is a valuable treatment option for patients with chronic shoulder instability who are elderly and either have poor glenoid bone stock or have undergone multiple failed stabilization procedures. Recurrent instability does not seem to be a major concern. The improvement over the preoperative state is comparable in the instability and rotator cuff tear groups.

Disclaimer

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