ORIGINAL STUDY

Reverse shoulder arthroplasty for patients with glenohumeral osteoarthritis secondary to glenoid dysplasia

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The purpose is to report the clinical and radiographic outcomes, complications and reoperations of reverse shoulder arthroplasty (RSA) for glenoid dysplasia. All patients who had undergone RSA for osteoarthritis secondary to underlying glenoid dysplasia were retrospectively identified. The study included twelve shoulders (11 patients), with a mean (SD) patient age of 62.2 (13.2) years and median (range) clinical follow-up of 28 (24-34) months. RSA resulted in substantial improvements in pain and function. At most recent follow-up, there was a significant improvement in forward flexion range of motion (ROM), a non-significant improvement in internal rotation ROM, and no changes in external rotation ROM. The mean (SD) SST and ASES scores were 7.8 (3.7) and 73.5 (20.4), respectively. There were no reoperations or radiographic loosening. The results were excellent in 1 case, satisfactory in 8, and unsatisfactory in 3. RSA provides acceptable function and good pain relief, though patients should be advised that shoulder rotation may be somewhat limited.

Keywords : glenoid displasia ; glenohumeral osteo-arthritis ; reverse shoulder ; shoulder arthroplasty.

INTRODUCTION

Glenoid dysplasia (GD) is an uncommon shoulder condition. While patients may remain asymptomatic for years, development of early osteoarthritis has been reported *(2,9,17)*. The treatment of shoulder osteoarthritis in GD has included physical therapy, glenohumeral stabilization, hemiarthroplasty, and total shoulder arthroplasty (TSA) *(1,2,5,12,13,17)*. Shoulder arthroplasty in patients with GD is very challenging due to limited glenoid bone. In fact, the outcomes of hemiarthroplasty and TSA in GD have been suboptimal because of continuing subluxation or dislocation, progression of glenoid osteoarthritis, glenoid component loosening, severe polyethylene wear, and glenoid component fracture *(1,2,5,13)*. Though the clinical and functional outcomes can

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be considered acceptable *(1,2,5)*, they appear to be inferior to shoulder arthroplasty for primary osteoarthritis. This led some authors to recommend alternative treatment options in patients with osteoarthritis secondary to GD *(1)*.

Reverse shoulder arthroplasty (RSA) may be a good surgical option for GD, as it has the potential to provide a more stable joint and decrease the risk of glenoid component complications, especially in the presence of glenoid bone stock abnormalities. However, the outcomes of RSA in patients with GD have not been reported to date. The purpose of this study was to report the clinical and radiographic outcomes, complications and reoperations of RSA for patients with GD.

PATIENTS AND METHODS

Procedures

Between January 2004 and December 2013, all patients undergoing RSA performed by the 3 senior surgeons (RHC, JSS and JVVS) were identified through our Institutional Total Joint Registry database. Inclusion criteria were : age above 18 years old, presence of GD, preoperative CT scan and plain radiographs, and a minimum 2 years of follow-up. The diagnosis of GD was reviewed and confirmed by two senior surgeons (JSS and JWS)
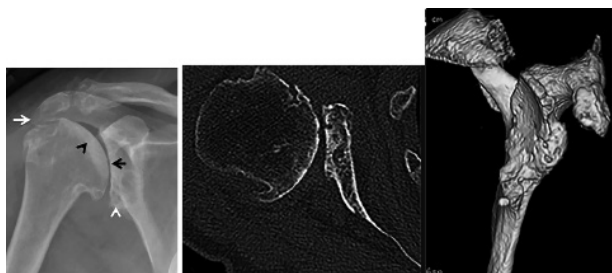

Figure 1. — Radiographic characteristics of glenoid dysplasia. A, Anterior-posterior plain radiograph demonstrating absence of scapular neck (white arrow head), enlarged, flat and irregular glenoid cavity (black arrow), dysplasia of the humeral head (black arrow head), and down-slopping of the acromion (white arrow). B, Axial plane of a CT scan view showing absence of the posterior glenoid with humeral head subluxation, subchondral sclerosis, subchondral cysts, and osteophytes. C, CT scan with 3D reconstruction showing the absence of formation of the posterior glenoid with excessive glenoid retroversion and osteophyte formation.

based on preoperative imaging studies and review of the surgical records. GD was defined as the presence of an elongated, flat, and irregular glenoid cavity, absence of scapular neck, down-slopping of the acromion, humeral head dysplasia, and lateral projecting or foreshortening of the coracoid process, with or without glenoid retroversion greater than 25° with posterior humeral subluxation (Walch Type C) (Figure 1A-C) *(8,9,15,17)*. All patients had 3D CT reconstructions to help understand the patient's anatomy and aid in preoperative planning (Figure 1A-C). After patients were identified, all relevant data for the present study were extracted through a retrospective chart review. After data collection, a radiographic assessment session was conducted in which all preoperative, early follow-up, and late follow-up radiographs were evaluated by 2 senior surgeons (JSS and JWS) blinded to the clinical outcomes. The study received IRB approval (Protocol ID 16-000153).

Patients

A total of 1,289 RSA procedures had been performed in the study period by the three senior surgeons. Of these, 15 cases of GD were identified in 14 patients. Three patients were excluded : two because they did not meet the radiographic criteria for GD, and one because of clinical follow-up less than 2 years. This left a total sample of 12 shoulders (in 11 patients). At most recent follow-up, five of the 12 shoulders were evaluated in clinic the rest through a validated Joint Registry follow-up questionnaire *(11)*. There were nine men and two women (one male had bilateral RSA) with a mean (SD) age of 62.2 (13.2) years (Table I). The mean (SD) of height, weight, and BMI was 1.72 (0.07) m, 98.3 (30.4) Kg and 33.2 (9.9), respectively (Table I). All patients were right-handed, with six RSA performed on the right side, and six on the left side (Table I). The median (range) of clinical follow-up was 28 (24-34) months. The median (range) radiographic follow-up was 31 (18-49) months. There were six cases with none, one with mild, three with moderate, and two with severe preoperative radiographic superior subluxation. There were four cases with moderate (one of them anterior), and

Table I. — Clinical and functional outcomes

Case	Age (years)	Gender	Surgery type	Follow-up (mos)	Preop pain	Postop pain	Preop elevation (°)	Postop elevation (°)	Preop external rotation (°)	Postop external rotation (°)	Neer rating	SST	ASES
1	83	Male	Primary	32	-	3	140	180	50	30	Satisfactory	7	66.63
2	72	Male	Primary	34	4	2	90	150	20	40	Satisfactory	12	98.33
3	55	Male	Primary	29	4	1	110	160	30	10	Unsatisfactory	11	83.32
4	68	Male	Primary	24	-	1	100	150	30	15	Unsatisfactory	-	-
5	70	Male	Primary	28	4	1	90	170	20	30	Satisfactory	11	95
6	64	Male	Primary	31	4	1	80	170	20	40	Satisfactory	10	75
7	65	Male	Primary	28	4	1	90	160	10	40	Satisfactory	10	75
8	75	Female	Primary	26	4	1	90	120	60	75	Satisfactory	2	73.3
9	64	Male	Revision	24	-		110	130	45	20	Satisfactory	-	-
10	40	Male	Revision	28	3	3	120	80	40	10	Unsatisfactory	2	28.34
11	43	Female	Revision	24	5	1	100	120	40	30	Satisfactory	8	75
12	48	Male	Revision	27	5	1	80	140	20	50	Excellent	5	65

ASES, American Shoulder and Elbow Society; SST, simple shoulder test.

seven cases with severe preoperative radiographic posterior subluxation (one patient did not have the preoperative axillary view radiograph). All cases had glenoid retroversion over 25° (Walch Type C).

Eight cases had primary RSA and four cases had revision RSA. One of the shoulders undergoing primary RSA had undergone a previous rotator cuff repair. One case of revision RSA was an infected TSA performed elsewhere who then underwent a two-stage revision arthroplasty to a RSA. The second revision RSA was in a patient initially treated with humeral head resurfacing revised to a TSA with bone graft who had a posterior dislocation, and underwent revision arthroplasty (conversion of TSA to RSA). The third revision RSA was in a patient with infected humeral head resurfacing who underwent two-stage revision arthroplasty (conversion of humeral head resurfacing to RSA). The fourth revision RSA was a patient initially treated with glenoid bone graft for posterior instability who was initially revised with a humeral head resurfacing and eventually underwent revision arthroplasty (conversion of humeral head resurfacing to RSA).

Surgical procedure

All RSA were performed through a deltopectoral approach. In all cases, eccentric (anterior) reaming was used to correct excessive glenoid retroversion. The starting point of the guide pin was positioned in the glenoid cavity where bone stock would provide optimal fixation. The glenoid component was placed in the most inferior part of the glenoid (Figure 2) in most shoulders. However, in some shoulders, placement was required slightly more proximal to achieve adequate surface for stable baseplate fixation and a glenosphere with inferior eccentricity was used to decrease humeral component-scapular impingement (Figure 3). In cases with more proximal position of the baseplate, care must be taken to avoid suprascapular nerve injury. In such cases, careful drilling (avoid sudden, uncontrolled penetration through the far cortex/bone), adequate drilling angle, and use of short locking screws is recommended to decrease the risk of suprascapular nerve injury. Occasionally in cases of severe deformity, patient-specific instrumentation was used

Figure 2. — Postoperative anterior-posterior plain radiograph. The baseplate could be placed inferior in the glenoid cavity, and there was no need for inferior glenosphere offset.

Figure 3. — Postoperative anterior-posterior plain radiograph. The baseplate was placed high in the glenoid cavity, and the glenosphere was placed with inferior offset to avoid humeral component-scapular impingement.

to place the glenoid component in anatomic version and to provide a better implant fixation. Bone graft was used in cases where the contact surface of the glenoid component with the native bone was less than 60% after glenoid reaming (Figure 4A). In all cases where bone graft was needed, the donor site was the patient's humeral head. Perforations spaced 2 mm apart were created in the area where reaming could not be possible to enhance bone-to-graft healing (Figure 4B). The bone autograft

was then placed where the bone deficiency was present (Figure 4C and 4D). The bone graft was not additionally fixed with independent screws but instead, either fixed through the baseplate screws or fixed press-fit when the baseplate fixation was finalized. In none of the cases the bone graft was found unstable after final baseplate fixation. In addition, the absence of additional screws for the bone graft also decreases the risk of suprascapular nerve injury.

Trial reduction was the primary method of managing soft tissue contracture secondary to severe preoperative medialization. Release and tenodesis of the biceps, release of the supraspinatus tendon, use of a less lateralized glenosphere and lowering of the humeral cut were the main means to deal with excessive soft tissue tension at the time of reduction.

The mean (SD) operative time was 85 (26) minutes. There were 11 Comprehensive ® Reverse Shoulder System prostheses (Biomet, Warsaw, IN) and one Delta XTend ® prosthesis (Depuy, Warsaw, IN). All primary RSA and one of the revision arthroplasty cases had the humeral component implanted in 30º of retroversion; humeral component version was not documented in the remaining three revision shoulders. For Biomet implants, six micro (9mm in one case, 10mm in one case, 12mm in two case, 14mm in one case, and 15mm in one case) and five mini (9mm in 1 case, 10mm in 2 cases, 11mm in 1 case, and 12mm in 1 case) stems were used. The standard humeral bearing surface 44x41mm was used in seven cases, the standard 44x36mm in three cases, and the 44x41mm +3 in one case. The mini 25mm baseplate was used in all cases. The standard 41mm glenosphere was used in six cases, the standard 36mm in four cases, and the 41mm +3 offset glenosphere in one case. For the Depuy implant, the 10mm stem size, 42mm +6 offset humeral cup, shell cementless metaglene, and standard 42mm glenosphere were used. The humeral stem was only cemented in one case (Depuy humeral stem). Bone autograft for the glenoid component was required in seven cases.

Outcome assessment

A retrospective chart review was performed to extract : 1) demographic characteristics, length of

Figure 4. — Intraoperative picture of the glenoid reaming in a patient with glenoid dysplasia. Panel A, Guide pin was placed in the desired location, and reaming could be done safely only in the anterior half (50%) of the glenoid (white arrows). Panel B, The dysplastic posterior half of the glenoid could not be reamed, and several 2mm-apart perforations were performed (black arrows). Panel C, Picture of humeral head bone autograft placed in the posterior aspect of the baseplate. Panel D, Final appearance of the baseplate implanted with bone graft in the posterior half (black arrows).

follow-up, and surgical history ; 2) preoperative pain (1=no pain ; 2=mild pain ; 3= pain with usual activities ; 4=moderate pain ; and 5=severe pain) and range of motion (ROM) ; 3) preoperative radiograph characteristics ; 4) characteristics of the surgical treatment (surgeon, operative time, implants used, and use of bone graft or cement) ; 5) postoperative pain and ROM ; 6) postoperative radiograph characteristics in the early and final follow-up ; 7) complications and reoperations ; 8) functional outcomes (Neer rating scale, simple shoulder test (SST), and American Shoulder and Elbow Surgeons (ASES) score) ; and 9) patient's satisfaction on a 0 to 10 scale (where 0 is not satisfied). According to the Neer rating system *(3,7)*, a result was considered excellent if the patient had no or slight pain, active abduction to 140°, and external rotation to 45°, and was satisfied with the procedure ; a result was satisfactory if the patient had no or slight pain or moderate pain only with vigorous activity, active abduction to 90°, external rotation to 20°, and the patient was satisfied with the procedure ; and a result was unsatisfactory if the criteria for satisfaction were not met or if the patient needed a further revision procedure.

Anterior-posterior and axillary plain radiographs were evaluated in the preoperative, immediate postoperative, and last follow-up periods. The data collection spreadsheet included confirmation of GD (type C glenoid according to the Walch classification or normal retroversion in cases of multiple epiphyseal dysplasia with presence of the other radiographic findings) *(16),* humeral head superior and posterior subluxation in all three periods, glenoid and humeral radiolucent lines, presence of scapular notching (classified according to Sirveaux et al.) *(10)*, presence of glenoid loosening, and shifting in position of the glenoid or humeral components. The degree of subluxation was categorized as none, mild (<25%), moderate (25%-50%), and severe (>50%). Glenoid radiolucent lines were classified as 0 (none), 1 (faceplate only), 2 (1mm incomplete), 3 (1mm complete), 4 (1.5mm incomplete), 5 (1.5mm complete), and 6 (2mm complete). Humeral radiolucencies were classified as 0 (none), 1 (1mm incomplete), 2 (1mm complete), 3 (1.5mm incomplete), 4 (1.5mm complete), 5 (2mm in 1-2 zones), 6 (2mm in 3-4 zones), and 7 (2mm complete). The presence of glenoid loosening was determined in consensus between the two senior surgeons involved in radiographic analysis (JSS and JWS).

Statistical analysis

Descriptive statistics were used to summarize the outcomes. Data were reported as number of cases (n), mean, median, standard deviation (SD), and range. Non-parametric tests were used for all preoperative-postoperative comparisons. A paired Wilcoxon test was used to compare preoperative and postoperative forward flexion and external rotation. The Fisher's exact test was used to compare preoperative and postoperative pain and internal rotation. The alpha level was set at 0.05. All the statistical analyses were conducted using the SPSS v.21 program (SPSS Inc., Chicago, IL, USA).

RESULTS

RSA resulted in substantial improvements in pain and function (Table I). The mean (SD) SST and ASES scores were 7.8 (3.7) and 73.5 (20.4), respectively (two missing values). The median (range) satisfaction was 8 (2-10). There was a significant improvement in forward flexion between the preoperative and postoperative periods : mean (SD) 100º (17.6) compared to 144º (28.1) ; p=0.0005 (Table I). With the numbers available, there were no statistically significant differences in pain, external rotation ROM, and internal rotation ROM between the preoperative and postoperative periods. The mean (SD) external rotation was 32.1º (15) preoperatively, and 32.5º (18.5º) postoperatively (p=0.6). Preoperative pain was 3 in one case, 4 in six cases, and 5 in two cases (three missing values), whereas postoperative pain was 1 in eight cases, 2 in one case, and 3 in two cases (one missing value) (p=0.07). The internal rotation ROM was L5 in two case, sacrum in seven cases, iliac crest in two cases, and sacroiliac joint in one case preoperatively, and L1 in one case, L2 in one case, L4 in one case, L5 in one case, sacrum in three cases, iliac crest in 2 cases, and hip in 2 cases postoperatively (one missing value) (p=0.8). At most recent follow-up, results were graded as excellent in 1 case, satisfactory in 8 cases, and unsatisfactory in 3 cases.

One patient had subjective feelings of instability, but all radiographs showed well located components. A second patient had persistent unexpected pain and
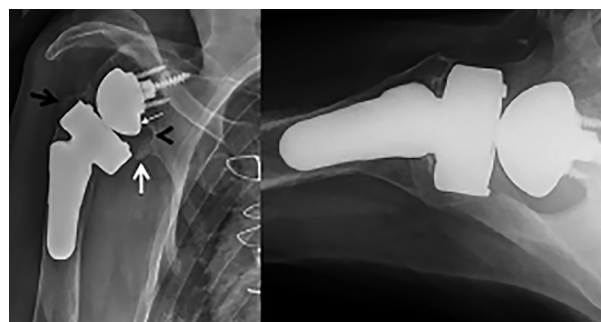

Figure 5. — Late postoperative plain radiographic follow-up. A, Anterior-posterior view demonstrating heterotopic bone formation (black arrow), glenosphere with inferior offset (thin white arrow), grade 1 scapular notching (black arrow head), and calcification of the triceps brachii insertion (thick white arrow). B, Axillary view demonstrating a well centered implant with correction of the excessive glenoid retroversion.

underwent a diagnostic arthroscopy 11 months after the RSA to obtain tissue samples for culture and rule out an infection. Sample cultures were negative for infection. This patient gradually improved the pain and at 2 years after the RSA it was only mild. There were no other reoperations in this series.

No patients had glenoid or humeral radiolucent lines or component loosening in either the early or the last radiographic follow-up. Two patients developed moderate heterotopic ossification, and four patients had asymptomatic calcification of the triceps brachii insertion close to the inferior rim of the glenoiud. There were two patients with asymptomatic grade 1 scapular notching (Figure 5A,B).

DISCUSSION

GD is an uncommon developmental anomaly of the scapula caused by incomplete ossification of the posterior-inferior aspect of the glenoid cavity and scapular neck *(4,15)*. Radiographic characteristics of GD typically include an absence of scapular neck with an enlarged, flat and irregular glenoid cavity. There are other commonly associated radiographic findings, including excessive glenoid retroversion, down-slopping of the acromion, humeral head dysplasia, lateral projecting, hooking of the lateral aspect of the clavicle, or forth-shorting coracoid process *(8,9,15,17)*. While some of these patients

Table II. — Comparison of outcomes across different studies

Study	Study characteristics	Pain*	FF**	ER**	IR*	Neer rating*
Sperling 2002[12]	N=7 (4 HA, 3 TSA) FU=88 months**	1= 3 (43) 2= 1 (14) 4= 2 (29) 5= 1 (14)	149º	49º	Average L3	E= 3 (43) U= 4 (57)
Edwards 2004[5]	N=15 (4 HA, 11 TSA) FU=37 months**	12.4/15 (Constant score)	146º	44º	-	-
Bonnevialle 2011[2]	N=10 (all HA) FU=71 months**	1= 4 (40) 2= 5 (50) 4= 1 (10)	124º	35º	Buttock= 1 (10) L5= 1 (10) L3= 2 (20) L1= 2 (20) T10= 2 (20) T7=2 (20)	E= 4 (40) S= 3 (30) U= 3 (30)
Allen 2014[1]	N=22 (8 HA, 14 TSA) FU=72 months**	1= 5 (23) 2= 7 (31) 3= 4 (18) 4= 5 (23) 5= 1 (5)	125º	42º	Average L3	E= 2 (9) S= 10 (45.5) U= 10 (45.5)
Present study	N=12 (all RSA) FU= 28 months**	1= 8 (67) 2= 1 (8) 3= 2 (17)	144º	32.5º	Hip= 2 (17) Iliac crest= 2 (17) Sacrum= 3 (25) L5= 1 (8) L4= 1 (8) L2= 1 (8) L1= 1 (8)	E= 1 (8) S= 8 (67) U= 3 (25)

* n (%). **Average. E, excellent ; ER, external rotation ; FF, forward flexion ; FU, follow-up ; HA, hemiarthroplasty ; IR, internal rotation ; N, number of cases ; RSA, reverse shoulder arthroplasty ; S, satisfactory ; TSA, total shoulder arthroplasty ; U, unsatisfactory.

may remain asymptomatic or develop only mild symptoms throughout their life, some patients have early development of shoulder osteoarthritis *(1,2,5,12,13).*

The treatment of early osteoarthritis secondary to GD includes physical therapy and shoulder arthroplasty *(11,2,5,12,13).* In cases of failed initial treatment with physical therapy, hemiarthroplasty or TSA are typically considered *(1,2,5,13).* Though both surgical options have provided somewhat favorable functional results, incomplete pain relief, glenoid wear, glenoid component loosening, and implant subluxation or instability have been an issue *(1,13).* To the best of our knowledge, there are no previous studies reporting the outcomes of RSA in patients with GD.

The results of the present investigation are comparable to previous studies using anatomic shoulder arthroplasty in GD (Table II). Our study had a limited sample size, but more patients than some of the previous studies *(2,13).* Treatment with RSA elicited better pain relief compared to hemiarthroplasty or TSA, as 66% had no pain at all compared to a range of 23% to 43% in previous studies (Table II). Our study had a low number of patients with an excellent result (8%) as observed by Allen et al. *(1)*, and was clearly inferior to other studies *(2,13).* However, our study had the highest rate of combined excellent or satisfactory results (Table II), and the lowest rate of unsatisfactory result (25%) compared to other studies (range between 30% and 57%) *(1,2,13)*. In our study, the reason for an unsatisfactory result in two of the three patients was only limited external rotation in patients with adequate pain relief and function (Table I). In fact, the external and internal rotation values in our study were lower than previous studies (Table II). Nonetheless, the results of the present study

demonstrate that RSA provided equal *(5,13)* or better forward flexion compared to hemiarthroplasty and TSA (Table II) *(1,2)*.

Our study reported fewer complications and reoperations than previous studies *(1,2,5,13)*. The lower rate of complications may be partly due to the fact that our study had shorter follow-up compared to some of the previous studies *(1,2,13)*. However, it might be argued that a median of 28 months would suffice to observe glenoid component failure (dissociation, fracture, or loosening) or instability should that have happened in relation to abnormal forces across the glenoid component or failure of bone ingrowth into the baseplate. Still, further research should report the outcomes of RSA in GD with long-term follow-up. In addition, future studies should report the outcomes of RSA using component-based glenoid augmentation, or compare the use of bone graft with component-based glenoid augmentation.

There is some controversy among surgeons whether to ream the glenoid to a neutral position and bone graft the posterior glenoid or place the baseplate in the patients' native retroverted position. Excessive medialization by asymmetrically reaming the glenoid can potentially become problematic, but this is mostly true for anatomic rather than RSA. We are aware that some surgeons prefer not to correct version at all and place the baseplate on the neoglenoid, but at this point we do not believe there is enough information in the literature to determine if one method is superior than the other. In general, the surgeons in the current study chose to ream the glenoid to a neutral position and bone graft the posterior glenoid with bone graft from the humeral head (Figure 4A-D). Intra-operatively, the surgeons have also the option of using glenosphere with different lateral offsets or using eccentric glenospheres to further adjust soft tissue tension. Adequate balance of the soft tissues is difficult in this long-standing condition due to tightening of the posterior capsule and rotator cuff. In some cases, posterior capsule release may be needed to help balance the soft tissues. In some others, a tendon transfer may be considered at the time of RSA to improve external rotation.

Lack of external rotation after RSA is multifactorial, particularly in patients with GD who have had abnormal bone and soft tissues for their entire life. Retracted posterior capsule, abnormal biomechanics in normally-appearing tendons of the posterior or posterior-superior rotator cuff, rupture or incompetent posterior or posterior-superior rotator cuff, excessive medialization, humeral component version, or humeral component neck-shaft angle can all be related to lack of external rotation in these patients. We do not believe the patients in the current series have a serious decrease in external rotation considering the difficult condition of GD, as evidenced by the mean postoperative external rotation of 32º, actual increase in postoperative external rotation compared to preoperative motion in 50% of the patients, external rotation less than 30º in only 4 patients, and lack of patients' complaints on this specific issue (except for 3 cases with external rotation of 10º, 10º, and 15º). It has been suggested that increased retroversion (40º) of the humeral component may create extra-articular impingement *(6)*. However, if impingement would have been a problem in the current series and explain lack of external rotation, patients with less than 30º external rotation would have had pain, and there was no pain in two of the three patients (Table 1). In addition, placing the humeral component anteverted would not be recommended because external rotation is significantly decreased *(14)* .

Our study has some limitations. First, this was a retrospective chart review study with limited sample size and short follow-up. Second, given the absence of a comparative group, we cannot determine if RSA is better than anatomic shoulder arthroplasty in patients with GD. Third, some of the patients had the last follow-up through a questionnaire instead of an office visit, though the questionnaire employed in our institution has been adequately validated.[11] On the other hand, our study is the first to report the outcomes of RSA in patients with glenohumeral osteoarthritis secondary to and demonstrates that this type of implant is a valuable treatment option to provide pain relief and improve function for these patients.

CONCLUSIONS

The results of RSA for patients with GD are satisfactory. Though RSA provides acceptable function and good pain relief, patients should be advised that shoulder rotation may be somewhat limited. Studies with longer follow-up are needed.

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