Original Article
Clinics in Orthopedic Surgery 2024;16:294-302 • https://doi.org/10.4055/cios23016

Complications and Reinterventions of Reverse Total Shoulder Arthroplasty in a Korean Population: 14-Year Experience in Reverse Shoulder Arthroplasty

Hwan-Hee Lee, MD, Dong-Whan Suh, MD, Jong-Hun Ji, MD, Hyun-Sik Jun, MD

Department of Orthopaedic Surgery, Daejeon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Daejeon, Korea

Background: There are few reports on the revision or reintervention of reverse total shoulder arthroplasty (RTSA) in South Korea. The purpose of this study was to evaluate the true incidence of complications and reintervention of RTSA and clinical and radiological outcomes based on our 14-year experience in RTSA in a Korean population.

Methods: Between March 2008 and June 2022, 412 consecutive cases of RTSA were performed in 388 patients with an average age of 74.4 years at our institute. Excluding 23 patients lost to follow-up, 365 patients (373 shoulders including 8 bilateral cases) who underwent primary RTSA with more than 6 months of follow-up were enrolled in this study. We evaluated those who had complications or reintervention including revision RTSA for failed RTSA. Patient charts were reviewed, and clinical outcomes including clinical scores, complications, and reintervention and radiologic outcomes were evaluated at the last follow-up.

Results: Among the 373 shoulders that underwent primary RTSA, complications were found in 50 patients (13.94%, 10 men and 40 women with a mean age of 75.9 ± 6.7 years [range, 51–87 years]). The causes of complications were as follows: 13 acromion, coracoid, or scapular spine fractures, 10 loosening (glenoid: 5, humeral stem: 5), 5 infections, 4 periprosthetic fractures, 2 instability, 2 neurologic complications, and 14 miscellaneous complications. Twenty patients (5.63%, 4 men and 16 women with a mean age of 74.2 ± 8.2 years [range, 51–87 years]) underwent reintervention. The interval to the first reintervention was 27.8 ± 23.1 months (range, 0.1–78 months). The causes of reintervention (20 cases) were 8 loosening (glenoid: 4, humeral stem: 4), 5 infections, 5 fractures, and 2 instability. Among them, 15 component revisions (4.02%) were performed. At the last follow-up, American Shoulder and Elbow Surgeons, University of California at Los Angeles, and Simple Shoulder Test scores were improved from 25.4, 12.4, and 1.6 preoperatively to 40.4, 16.2, and 3.2, respectively. Forward flexion (48° to 87°), abduction (52° to 79°), external rotation (18° to 22°), and internal rotation (buttock to L2) were improved.

Conclusions: After primary RTSA in a Korean population, the complication, reintervention, and revision rates were 13.94%, 5.63%, and 4.02%, respectively. Careful evaluation of the complications and adequate treatments should be performed.

Keywords: *Total shoulder arthroplasty, Complications, Revision, Korean population*

Received January 16, 2023; Revised April 21, 2023;
Accepted April 21, 2023
Correspondence to: Jong-Hun Ji, MD
Department of Orthopaedic Surgery, Daejeon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 520-2, Deahung-Dong, Joong-Ku, Daejeon 302-803, Korea
Tel: +82-42-220-9530, Fax: +82-42-221-0429
E-mail: jijh87@gmail.com

Reverse total shoulder arthroplasty (RTSA) has become a valuable treatment option for rotator cuff arthropathy, irreparable rotator cuff tears associated with or without osteoarthritis or proximal humeral fractures, and fracture sequelae. The use of RTSA has increased over the last 20 years and is still growing. Although primary RTSA has shown promising results, several complications of RTSA are often reported.[1] Complication rates after conventional TSA were reported to be 12% to 14.7% and prosthetic loosening was the most common complication in TSA.[2-4] Compared to TSA, RTSA had higher complication rates (8%–22%), and scapular notching and instability were the most common complications.[5,6] A complication was defined as any intraoperative or postoperative event that was likely to have a negative influence on the patient's final outcome. Unique complications of RTSA included scapular notching, instability, glenoid component loosening, acromial or scapular spine fractures, hematoma formation, and glenoid dissociation (Fig. 1). For the treatment of these complications, reintervention was performed. Previously, the definitions of complications and reinterventions including reoperations and revisions were described by Zumstein et al.[6] Reinterventions were subcategorized into reoperations and revisions. Reoperations were defined as interventions requiring any return to the operating room for any reason relating to the shoulder, without altering or replacing any of the components. Among them, revision surgery included (1) replacement of whole or one component, including bearing, metaphysis, glenoid, or humeral stem, (2) resection arthroplasty (to remove all implants), or (3) conversion to hemiarthroplasty. Reintervention included fixation of the periprosthetic, acromial, or scapular spine fracture, closed reduction of the prosthesis dislocation or open reduction of periprosthetic fracture or acromion fracture, or prosthesis with antibiotic-loaded acrylic cement (PROSTALAC) insertion due to infection (Fig. 2). During the reintervention of RTSA, severe soft-tissue scarring, contracture, or large bone defect interfering with proper revision surgery, resection arthroplasty, or hemiarthroplasty conversion could be considered as another salvage procedure.

The most common causes of revision surgery after RTSA are as follows in decreasing order: prosthetic instability (38%), infection (22%), humeral problems (21%) including loosening, unscrewing, and fractures, and lastly, problems of glenoid loosening (13%).[5,6] Compared to TSA, loosening or instability were more common in

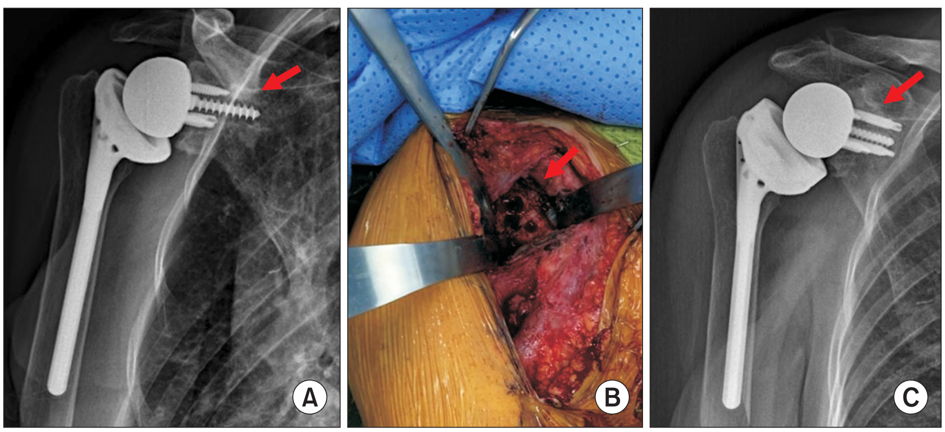

Fig. 1. An 83-year-old woman complained of severe shoulder pain after primary reverse total shoulder arthroplasty. (A) The X-ray showed a typical screw loosening of the glenosphere (arrow). (B) The intraoperative photograph showed an enlarged screw hole (arrow) on the glenoid. (C) Revision of the glenosphere with screw change (arrow) and iliac bone graft was performed.

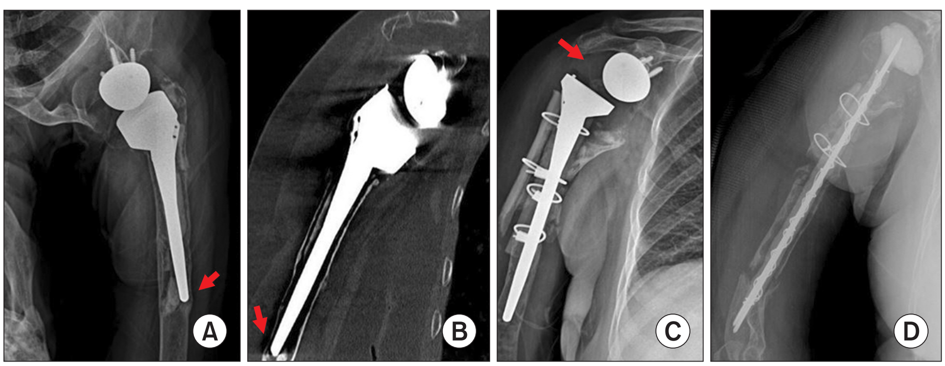

Fig. 2. (A, B) In a 73-year-old woman, the X-ray and computed tomography scan images showed a periprosthetic fracture (arrows) due to humeral stem loosening. (C) In the revision surgery of humeral stem loosening, the whole humerus allograft was used in the humeral bone defect and also glenohemeral dislocation (arrow) was found. (D) At postoperative 7 months, glenohumeral dislocation with infection developed and then prosthesis with antibiotic-loaded acrylic cement insertion was performed after failed conservative management.

RTSA[7-9] and the infection incidence of TSA and RTSA was 0.5% to 1% and 0% to 15.3% (mean, 5.1%), respectively.[10,11] However, compared to the previous study of early design RTSA, the recent revision rate of RTSA decreased due to the improved instruments, designs, and surgical skills.

There was little information of the reintervention or revision surgery of RTSA in Asian population. In South Korea, the first introduction of RTSA (Aequalis; Tornier, Minneapolis, MN, USA) was in late 2007 and RTSA has been the most popularized procedure for the rotator cuff arthropathy or massive rotator cuff tears with pseudoparalysis during more than 10 years. Compared to that in a previous study,[12] the recent revision rate for RTSA has been increased in South Korea. Knowing the exact incidence of complications or reintervention rates of RTSA in the Korean population is very helpful to the surgeon in treatment planning or patient care.

The purpose of this study was to evaluate the true incidence of complications and reintervention of RTSA based on our 14-year experience in RTSA and to report its clinical and radiological outcomes in a South Korean population. We hypothesized that patients treated with revision surgery were not satisfied with their clinical outcomes.

METHODS

This study was approved by the institutional review board, which waived the requirement for participant informed consent owing to the retrospective nature of the study (No. DC18RESI0026).

Between March 2008 and June 2022, 412 consecutive RTSAs were performed in 388 patients with an average age of 74.4 years at Daejeon St. Mary's Hospital. Catholic University of Korea. Twenty-three patients were lost to follow-up and finally, 373 shoulders (365 patients) that received primary RTSA (bilateral RTSA: 8 patients) were enrolled in this study. All patients who were followed up for more than 6 months (average, 36 months; range, 6–120 months) were included in our study. Among them, we evaluated patients who had complications or underwent reintervention including revision RTSA for failed RTSA and these patients who underwent reintervention were followed up for more than 2 years. Patient charts were reviewed and outcomes assessed included shoulder range of motion (ROM), clinical scores, and complications and reintervention. We also evaluated clinical and radiologic outcomes including X-ray, computed tomography (CT), or magnetic resonance imaging (MRI). We evaluated patients who had complications and also underwent reintervention including revision RTSA for failed RTSA.

The inclusion criteria for the study cohort were patients who had complications after primary RTSA and underwent reintervention or revision RTSA. All patients had a minimum follow-up of 1 year (range, 12–120 months) after reintervention or revision surgery (Table 1). The exclusion criteria were shoulder arthroplasty (total shoulder arthroplasty or hemiarthroplasty) except RTSA. In this study, 5 different prosthesis systems were implanted: Aequalis reversed shoulder prosthesis including BIO-RSA (Tornier), Encore reverse shoulder prostheses (DJO Global, Austin, TX, USA), Comprehensive reverse shoulder prostheses (Biomet, Warsaw, IN, USA), Aequalis ascend flex reverse shoulder prostheses (Tornier) and the Equinox system (Exactech, Gainesville, FL, USA). The Aequalis was used in 67 shoulders, BIO-RSA was used in 70 shoulders, the Ascend system was used in 126, Biomet was used in 27 shoulders, DIO was used in 20 shoulders, and Equinox was used in 101 shoulders.

All patients were intended to be treated with reintervention with a plate, PROSTALAC, revision, or resection arthroplasty. Reintervention including revision surgery included metaphysis insertion to the stem in dislocation,

Table 1. Patient Demographics in Reverse Total Shoulder Arthroplasty (373 Cases from March 2008 to March 2021)

Variable	Primary reverse total shoulder arthroplasty	Complication	Reintervention
Number of patients	373	50	20
Age (yr)	74.4 ± 8.8 (56–93)	75.9 ± 6.7 (51–87)	74.2 ± 8.2 (51–87)
Sex (male : female)	72 : 305	10 : 40	4 : 16
BMI (kg/m^2)	24.7 ± 3.8 (15.3–38.8)	25.5 ± 3.7 (15.3–34.6)	24.5 ± 4.9 (15.3–34.6)
Operative hand (right : left)	251 : 122	29 : 21	10 : 10

Values are presented as mean ± standard deviation (range).
BMI: body mass index.

open reduction and internal fixation of the periprosthetic fracture or acromion fracture, PROSTALAC insertion in the infected RTSA, or revision or resection arthroplasty. Among reintervention, we defined revision surgery as component reimplantation or component change, hemiarthroplasty conversion, and resection arthroplasty after a prior failed RTSA. In particular, revision RTSA procedures included revision of the components including the glenosphere, humeral stem, bearing, or metaphyseal block. In our study, patients were sometimes reoperated on several times due to persistent or new complications: 3 patients were reoperated more than three times.

Regarding complications of RTSA, we described the most important cause of these complications as the primary cause of the revision surgery. If X-ray showed humeral stem loosening and periprostatic fracture simultaneously, the primary cause of this loosening combined with the periprosthetic fracture was humeral stem loosening. This periprosthetic humeral fracture often developed secondarily due to the humeral stem loosening. Radiographs were taken at immediate postoperative, postoperative 3 months, 6 months, and 1 year, and last follow-up and they were reviewed for the comparison of previous X-ray. Demographic data, clinical data including pain visual analog scale (VAS), American Shoulder and Elbow Surgeons (ASES), University of California at Los Angeles (UCLA) and Simple Shoulder Test (SST) scores, ROM, radiologic outcomes, and complications were evaluated.

All patients underwent preoperative physical examinations and pre- and postoperative clinical evaluations were also performed regularly at the outpatient clinic. Last follow-up values were compared with preoperative values. Subjective pain was assessed by using the VAS for pain. Shoulder joint ROM was evaluated based on the preoperative and postoperative forward flexion, external rotation, internal rotation, and abduction data. Assessment of clinical outcomes was conducted by using UCLA shoulder score, ASES score, and SST score.

Statistical Analysis

SPSS software version 20.0 (IBM Corp., Armonk, NY, USA) was used for all statistical analyses. All means and standard deviations were checked for normal distribution using Shapiro-Wilk test. Categorical data were reported as numbers with percentages for proportions. Pearson's chi-square test was used to compare differences of categorical variables. Preoperative and postoperative values were compared using paired *t*-tests or Wilcoxon signed-rank test. Because of the small sample size in RTSA complications, continuous measures were analyzed using Mann-Whitney *U*-test. For all analyses, statistical significance was set to a *p*-value of less than 0.05.

RESULTS

During our 14-year experience in primary RTSA, complications (13.40%, 50/373 cases), reintervention cases (5.36%, 20/373 cases), and revision surgery (4.02%, 15/373 cases) were observed. At the final follow-up, complications were found in 50 patients (13.40%) among 373 primary RTSA cases. They were 10 men and 40 women with a mean age of 75.9 ± 6.7 years (range, 51–87 years). The causes of complications were as follows: 13 acromion, coracoid, or scapular spine fractures (Fig. 3), 10 loosenings (glenoid: 5, humeral stem: 5), 5 infections (*Escherichia coli*: 1, methicillin-resistant *Staphylococcus aureus* [MRSA]: 1, unidentified: 3), 4 periprosthetic fractures, 2 instability, 2 neurologic complications, and 14 miscellaneous complications such as heterotrophic ossification.

Among them, reintervention of RTSA was performed in 20 patients (5.63%). They were 4 male and 16 female patients and their mean age was 74.2 ± 8.2 years (range, 51–87 years). The interval to the first reintervention was 27.8 ± 23.1 months (range, 0.1–78 months). The causes of reintervention were as follows: 8 loosenings (glenoid: 4, humeral stem: 4), 5 infections, 5 fractures (1 acromion fracture and 4 periprosthetic fractures), and 2 instability. Among them, 15 revisions (4.02%, 15/373

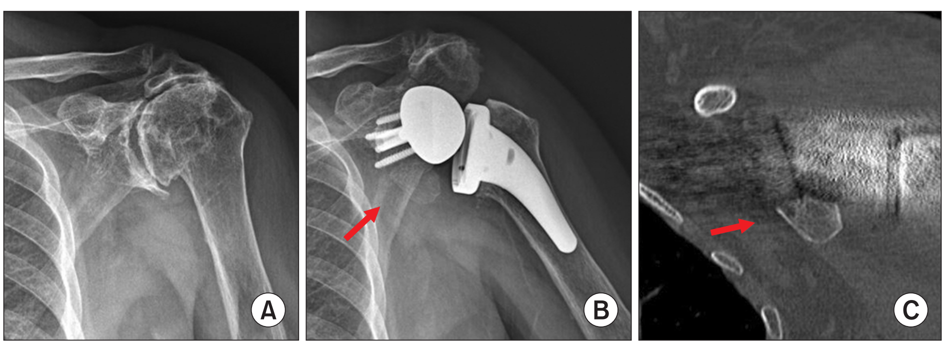

Fig. 3. (A) In a 76-year-old female patient, X-ray showed severe glenohumeral osteoarthritis. (B) After curved short stem (lateralized humeral stem) insertion in the reverse total shoulder arthroplasty, an avulsion fracture of the coracoid process (arrow) was found. (C) Computed tomography scan showed an avulsion fracture of the coracoid process fracture (arrow).

Table 2. Complications and Reintervention Rates of Reverse Total Shoulder Arthroplasty (373 Cases from March 2008 to March 2021)

Variable	Value
Number of reverse total shoulder arthroplasty	373 cases
Postoperative complication	50 (13.40)
Instability	2 (0.54)
Infection	5 (1.34)
Loosening	10 (2.68): conservative treatment in 2 patients
Glenoid loosening	5 (1.34)
Humeral loosening	5 (1.34)
Acromion, coracoid, scapular spine, and neck fracture	13 (3.49)
Periprosthetic fracture	4 (1.07)
Neurologic complication	2 (0.54)
Miscellaneous (heterotrophic ossification)	14 (3.75)
Reintervention	20 (5.36)
Reoperation	5 (1.34): 4 Periprosthetic + 1 acromion fracture
Revision of components	15 (4.02): 8 loosening (3 glenoid + 5 humeral stem) + 2 instability + 5 infection

cases) were performed (Table 2). Among these 20 patients, we analyzed the complications of each implant by company: Aequalis reversed shoulder prosthesis (Tornier) in 11 patients, Encore reverse shoulder prostheses (DJO Global, Austin, TX, USA) in 4 patients, Comprehensive reverse shoulder prostheses (Biomet, Warsaw, IN, USA) in 3 patients, and Aequalis ascend flex reverse shoulder prostheses (Tornier) in 2 patients.

Clinical Outcomes

Overall, all patients were satisfied with the results of revision surgery except 2 patients. The VAS score for pain was improved from 5.6 preoperatively to 3.8 postoperatively. There were increases in the mean active forward flexion (from 48° to 87°), abduction (from 52° to 79°), external rotation (from 18° to 22°), and internal rotation (from buttock to L2) postoperatively. The mean ASES score improved from 25.4 preoperatively to 40.4 postoperatively. The mean UCLA score improved from 12.4 preoperatively to 16.2 postoperatively. The mean SST score improved from 1.6 preoperatively to 3.2 postoperatively (Table 3).

Table 3. Clinical Outcomes after Revision Reverse Total Shoulder Arthroplasty (373 Cases from March 2008 to March 2021)

Variable	Preoperative	Postoperative	*p*-value
Clinical outcome			
Pain VAS	4.1 ± 19.0	1.6 ± 1.8	0.000
ASES	7.5 ± 12.0	37.3 ± 33.7	0.003
UCLA	3.0 ± 5.5	12.0 ± 12.7	0.004
SST	0.5 ± 0.9	3.2 ± 3.4	0.005
Range of motion			
Forward flexion	56.9 ± 35.0	89.1 ± 56.1	0.002
Abduction	43.1 ± 33.6	69.5 ± 61.1	0.041
External rotation	14.4 ± 12.7	17.1 ± 17.2	0.422
Internal rotation	Sacrum–L3	Buttock-T10	0.001

VAS: visual analog scale, ASES: American Shoulder and Elbow Surgeons, UCLA: University of California at Los Angeles, SST: Simple Shoulder Test.

Radiologic Outcomes

In the postoperative radiological evaluation, radiolucent lines were often observed around the humeral stem and glenoid component. These radiolucent lines did not cause any loosening of the humeral stem and glenoid component. However, humeral stem loosening was combined with the periprosthetic fracture in 2 cases. Cemented humeral stems might have caused loosening. Removal of humeral stems and long humeral stem revision were performed and then the thin humeral bone was augmented by split humeral allograft. This humeral stem revision showed good bony union at 2-year follow-up (Fig. 4). Another humeral stem loosening combined with a periprosthetic fracture led to an infection and finally resection arthroplasty was performed. The primary cause of this humeral loosening might have been a low-grade infection and prolonged humeral loosening led to the periprosthetic humeral fracture.

Another radiologic finding was postoperative fractures in 13 patients. These postoperative fractures included 11 acromion fractures, 1 scapular neck fracture, and 1 coracoid process fracture. According to the postoperative acromial fracture classification by Levy et al.,[13] 4 type I fractures, 6 type II fractures, and 1 type I + II fracture were found. Among them, 1 acromial fracture (type II) was operated.

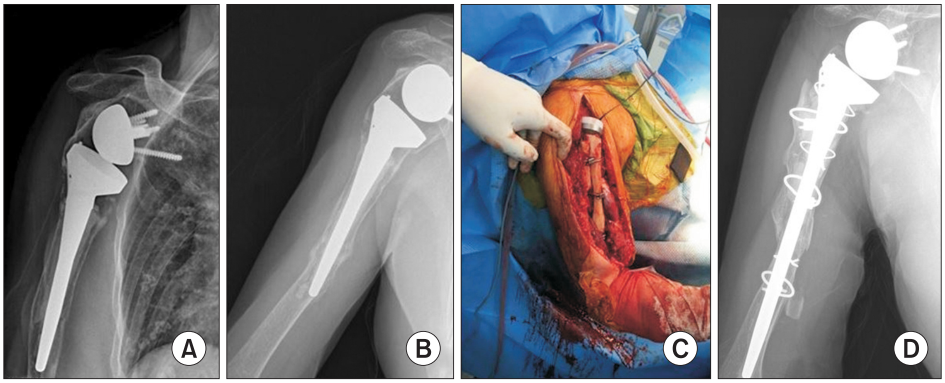

Fig. 4. (A) A periprosthetic humeral fracture developed, and the primary cause of this fracture was humeral stem loosening. (B) Long humeral stem revision with whole humeral allograft was performed. (C) Severe humeral bone loss was found during humeral stem removal, and the revision long humeral stem was covered with a longitudinally split humeral allograft using cables. (D) Two years later, allograft was well incorporated to the native humeral bone.

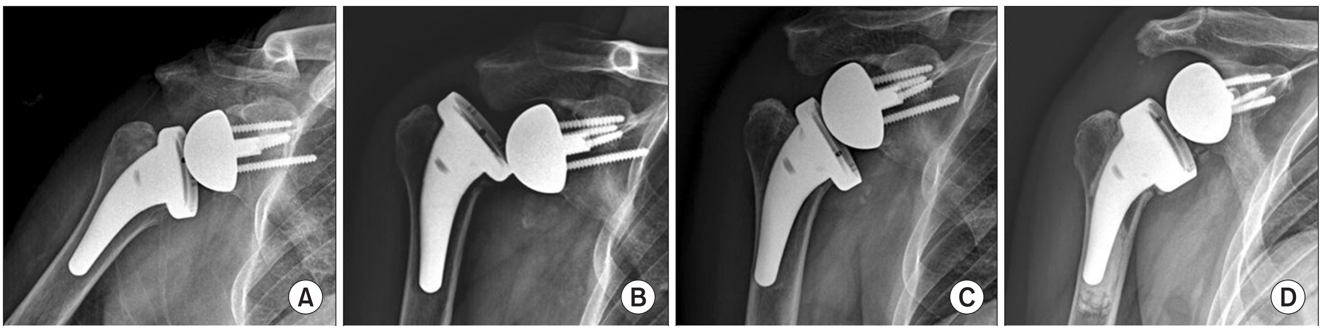

Fig. 5. (A, B) A 65-year-old man complained of recurrent shoulder dislocation after primary reverse total shoulder arthroplasty. (C) At 6 months postoperative, X-ray showed humeral stem loosening around the humeral metaphysis. (D) Revision surgery was performed using an augmented metaphysis and cemented stem.

Treatment for Patients Who Underwent Revision Surgery

Resection arthroplasty was performed after several re-revision surgery or in high-risk patients. In 2 patients who developed severe humeral bone defect after humeral loosening of the failed RTSA, resection arthroplasty was performed. These patients had several causes of revision surgery such as stem loosening combined with low-grade infection. Among them, 1 patient underwent revision using a whole humeral allograft at 2 years after resection arthroplasty.

Shoulder instability (dislocation) developed in 2 patients. Among them, metaphyseal block addition was performed for maintaining tight joint after first dislocation in the early postoperative period in 1 patient. One patient suffered from chronic recurrent dislocation 4 months after RTSA. This patient was a chronic alcoholic and multiple traumas of the shoulder joint caused multiple dislocation in which uncemented stem loosening developed. Revision arthroplasty using a cemented humeral stem and metaphysis augmentation was performed (Fig. 5).

Loosening developed in 10 patients; however, glenoid or humeral component revision was performed in 8 patients. Conservative treatment was performed in 2 patients with glenoid loosening. Glenoid component revision using iliac bone graft or allograft was performed in 3 patients. Humeral component revision using a long humeral stem was performed in 5 patients. These humeral stem revisions were often augmented with humeral allografts. For the glenoid loosening, 1 patient showed superior tilting of the glenoid component at initial surgery and finally, glenoid loosening developed due to the shear force to the glenosphere. In the revision surgery, inferior tilting of the glenoid component was performed. For glenoid loosening and glenoid bone defect, achieving an adequate size of glenoid graft was so difficult that we used BIO-RSA system (Tornier, Bloomington, MN, USA) for getting an adequately sized autograft. This autograft was inserted into the glenoid baseplate and impacted to the native glenoid bone.

For the periprosthetic fracture with humeral stem loosening in 2 patients (0.05%), long humeral stem revision with whole humeral allograft was performed. This periprosthetic humeral fracture often developed secondarily due to humeral stem loosening.

Infections were found in 5 patients. The culture

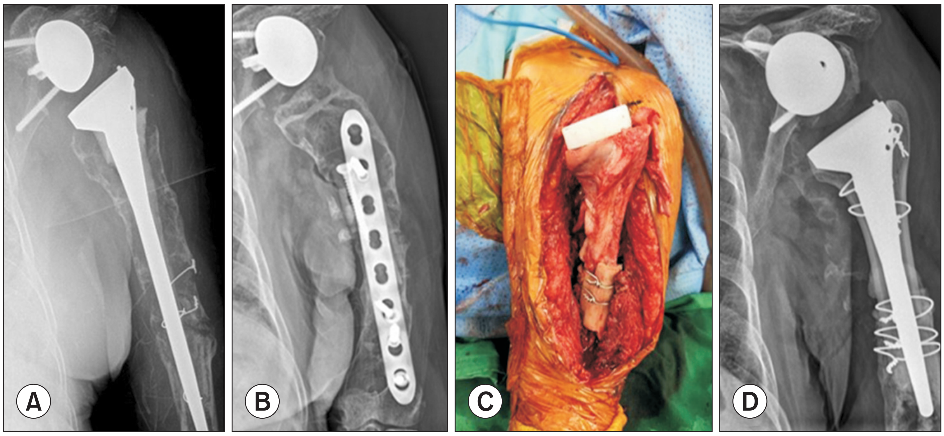

Fig. 6. (A) A 68-year-old woman complained of shoulder pain 5 years after primary reverse total shoulder arthroplasty. X-rays showed a periprosthetic fracture, and long stem revision arthroplasty was performed. (B) At postoperative 5 years, severe humeral stem loosening was noted and stem removal with fracture fixation using plate was performed. (C, D) An allograft prosthesis composite-revision arthroplasty was performed using a long humeral stem and whole humeral allograft.

results were as follows: *E. coli* in 1 patient, MRSA in 1 patient, unidentified in 3 patients. During the revision surgery, 1 patient tried to use the iliac bone autograft for the glenoid bone defect, but she suffered from an anterior superior iliac spine avulsion fracture at postoperative 1 month and bone healing was achieved 8 weeks after conservative treatments. In another patient with RTSA infection, delayed infection developed at postoperative 4 months. We suspected inadequate insertion of the glenoid component might cause movable glenosphere and finally delayed infection. During the operation, we could find disassembly of the glenosphere from the baseplate and removed the glenosphere from the baseplate easily. We took care with the use of the locking system of the glenosphere to the baseplate (manufacturer dependent) and confirmed adequate insertion and assemble of the glenosphere to the baseplate. In this case, second stage revision arthroplasty was performed after initial PROSTALAC insertion. Resection arthroplasty was done in 2 patients. Among them, 1 patient underwent allograft prosthesis complex revision surgery after an infection was controlled (Fig. 6).

Two patients suffered from brachial plexus injury or axillary neuropathy 5 months after RTSA. After brachial plexus injury, recurrent dislocation of the prosthesis developed. Closed observation and physiotherapy were done, but symptoms did not improve. In 1 patient with axillary neuropathy, complete resolution of the symptom was achieved.

DISCUSSION

During our 14 years of experience in primary RTSA in a South Korean population, the complication rate was 13.40%, the reintervention rate was 5.36%, and the revision rate was 4.02%. The causes of the complications were as follows: 13 acromion, coracoid, or scapular spine fractures, 10 loosenings (humeral stem: 5, glenoid: 5), 5 infections, 4 periprosthetic fractures, 2 instability, 2 neurologic complications, and 14 miscellaneous complications such as heterotrophic ossification. Fifteen component revisions (8 loosenings, 5 infections, and 2 instability) were performed. For the successful treatment of complicated RTSA, careful evaluation of complication's causes and adequate treatments should be performed.

Recently, RTSA can be often used for rotator cuff arthropathy, irreparable rotator cuff tears, revision surgery for failed TSA, or a complex proximal humeral fracture and its sequalae. As the incidence of primary RTSA increases, the need for revision RTSA is also increasing. Previously, resection arthroplasty, arthrodesis, hemiarthroplasty, and total shoulder arthroplasty had been performed for revision surgery, but they failed to show reliable pain relief or functional improvements.[12] Revision RTSA should be considered for several failed circumstances. Huge humeral or glenoid bone defect, too small glenoid size, or uncontrolled infection made revision surgery difficult. Revision surgery of RTSA was so difficult because fibrotic scar tissue and adhesion made wound dissection difficult and removal of humeral or glenoid components resulted in severe bone defects in the humerus or glenoid. Since the first introduction of RTSA in South Korea in 1997, RTSA has shown favorable clinical outcomes in the short-term follow-up.[14,15] However, the report of revision RTSA in the Korean population has been rare until now.

There are several causes of failed RTSA: glenoid or humeral component loosening, instability, infection, and dissociation of glenoid components. In our study, glenoid or humeral component loosening was the most common cause of revision RTSA. Loosening of the glenosphere or humeral stem was shown as radiolucency around the components. Follow-up X-ray and CT scans could be used to find the radiolucent lines. However, the presence of radiolucent lines did not correlate exactly with the inferior clinical outcomes at the last follow-up.

During revision, bone grafting was the most critical procedure for the successful revision. In the glenoid revision, severe glenoid defects occurred and humeral head allografts or iliac autografts were often used. It is very important to determine the need for a glenoid bone graft at the time of surgery after evaluating the glenoid bone quality before revision of the glenoid component.[16] Preoperative CT scans should be evaluated to identify glenoid defects for determining whether a bone graft is required or not. However, the CT image was interfered with the artifact of the glenoid component. If a sizable glenoid bone loss developed after the glenoid component was removed, BIO-RSA system (Tonier) allowed an iliac bone autograft or a humeral head allograft to mimic the glenoid defect. These prepared grafts could be inserted and impacted into the glenoid defect. For the large humeral bone defect due to severe humeral stem loosening, whole humeral allografts or allograft prosthesis composite grafts could be used.

Several authors reported rare clinical outcomes of revision RTSA. Jo et al.[11] reported 1 case of revision RTSA due to infections. Black et al.[16] reported 16 revision RTSA cases due to baseplate failure (7 patients, 43.8%), instability (6 patients, 37.5%), infection (2 patients, 12.5%), and humeral loosening (1 patient, 6.3%). Boileau[7] reported 60 cases of revision RTSA and the most common causes of revision surgery were prosthetic instability (38%), infection (22%), humeral problems (21%) including loosening, unscrewing and fracture, and, lastly, problems of glenoid loosening (13%). Farshad et al.[17] reported 67 cases of revision RTSA with the cause of instability (18%), hematoma or superficial wound complications (15%), and complications of the glenoid component (12%).

Compared to primary RTSA, revision RTSA has been associated with a lower quality of life, lower satisfaction, and a higher prevalence of complications. However, in a recent retrospective case-control study of patients 65 years or younger undergoing RTSA as either a primary or revision arthroplasty, authors found no significant differences between the 2 groups.[7] Most revision RTSA showed poorer clinical outcomes than primary RTSA.[14] However, considering inferior clinical outcomes of both hemiarthroplasty or resection arthroplasty, we still recommend revision RTSA for failed RTSA. However, we should discuss the benefits or hazards of revision RTSA with old aged patients and their family before revision surgery. Despite superior clinical outcomes of revision RTSA, patient factors such as patient's volition or medical comorbidity, surgical factors such as adequate device, poor quality of bone, and soft tissue should be considered all together.

In our study, the clinical results of revision RTSA improved significantly than those before surgery. This was probably due to the appropriate selection of revision surgery indications and complete setting of devices or bone grafts. In our series, specific consideration was required for the assessment of the proximal humeral bone loss during the revision surgery. Except for some cases with glenoid problems or infections, long humeral stems with whole humeral allografts should be essential for the successful humeral stem revision. Appropriate preparation of allografts in the proximal humeral bone defect or loss was the essential factor for the successful revision surgery in our study. Garcia-Fernandez et al.[18] reported that the incidence of periprosthetic humeral fractures associated with RTSA was 3.4% in 203 RTSAs. Our incidence of the periprosthetic humeral fractures was lower (1.07%) than that in the previous study and the causes might be the lower operation number and adequate osteoporotic management in the recent patient populations.

There were several limitations of our study. The first limitation was the small patient number with short-term follow-up (minimum 6 months). Second, compared to the Caucasian people, patients who have failed arthroplasty previously or revision arthroplasty are relatively rare and then revision surgery are less commonly performed in South Korea. This could be another major limitation of our review study. However, recently, more primary RTSAs are being performed and revision surgery of RTSA is increasing accordingly. Third, this study may not represent South Korea's RTSA results as it included a very heterogenous population with proximal humerus fractures and several different implant designs were used. However, we believe the strength of this study is that one surgeon performed all RTSA cases in one hospital during 14 years, which reflect our efforts to limit selection bias. Fourth, we decided the most important failure cause of the revision surgery as the primary failure cause of RTSA. However, this study included patients with multiple failure causes, including loosening, low-grade infection, and instability, which made the analysis of the failure causes difficult. All these could be limitations of this study. Long-term follow-up studies involving more patients are needed.

During the 14 years of experience in primary RTSA of the Korean population, the complication rate was 13.94%, the reintervention rate was 5.63%, and the revision rate was 3.75%. The causes of the complications of RTSA were as follows: 13 acromion, coracoid process, or scapular spine fractures, 10 loosenings (humeral stem: 5, glenoid: 5), 5 infections, 4 periprosthetic fractures, 2 instability, 2 neurologic complications, and 15 miscellaneous complications. For the successful treatment of complicated RTSA, careful evaluation of complications' causes and adequate treatments should be performed.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Hwan-Hee Lee https://orcid.org/0000-0002-6779-8075
Dong-Whan Suh https://orcid.org/0000-0003-3029-2553
Ji Jong-Hun https://orcid.org/0000-0003-1087-3254
Hyun-Sik Jun https://orcid.org/0000-0003-4194-8511

REFERENCES

1. Galvin JW, Kim R, Ment A, et al. Outcomes and complications of primary reverse shoulder arthroplasty with minimum of 2 years' follow-up: a systematic review and meta-analysis. J Shoulder Elbow Surg. 2022;31(11):e534-44.
2. Bohsali KI, Wirth MA, Rockwood CA Jr. Complications of total shoulder arthroplasty. J Bone Joint Surg Am. 2006; 88(10):2279-92.
3. Cheung EV, Sperling JW, Cofield RH. Revision shoulder arthroplasty for glenoid component loosening. J Shoulder Elbow Surg. 2008;17(3):371-5.
4. Antuna SA, Sperling JW, Cofield RH, Rowland CM. Glenoid revision surgery after total shoulder arthroplasty. J Shoulder Elbow Surg. 2001;10(3):217-24.
5. Coste JS, Reig S, Trojani C, Berg M, Walch G, Boileau P. The management of infection in arthroplasty of the shoulder. J Bone Joint Surg Br. 2004;86(1):65-9.
6. Zumstein MA, Pinedo M, Old J, Boileau P. Problems, complications, reoperations, and revisions in reverse total shoulder arthroplasty: a systematic review. J Shoulder Elbow Surg. 2011;20(1):146-57.
7. Boileau P. Complications and revision of reverse total shoulder arthroplasty. Orthop Traumatol Surg Res. 2016;102(1 Suppl):S33-43.
8. Ma GC, Bradley KE, Jansson H, Feeley BT, Zhang AL, Ma CB. Surgical complications after reverse total shoulder arthroplasty and total shoulder arthroplasty in the United States. J Am Acad Orthop Surg Glob Res Rev. 2021;5(7):e21.
9. Kiet TK, Feeley BT, Naimark M, et al. Outcomes after shoulder replacement: comparison between reverse and anatomic total shoulder arthroplasty. J Shoulder Elbow Surg. 2015; 24(2):179-85.
10. Sperling JW, Kozak TK, Hanssen AD, Cofield RH. Infection after shoulder arthroplasty. Clin Orthop Relat Res. 2001;(382):206-16.
11. Jo SH, Kim JY, Cho NS, Rhee YG. Reverse total shoulder arthroplasty: salvage procedure for failed prior arthroplasty. Clin Orthop Surg. 2017;9(2):200-6.
12. Ji JH, Jeong JY, Song HS, et al. Early clinical results of reverse total shoulder arthroplasty in the Korean population. J Shoulder Elbow Surg. 2013;22(8):1102-7.
13. Levy JC, Anderson C, Samson A. Classification of postoperative acromial fractures following reverse shoulder arthroplasty. J Bone Joint Surg Am. 2013;95(15):e104.
14. Ji JH, Shafi M, Jeong JJ, Ha JY. Reverse total shoulder arthroplasty in the treatment of chronic anterior fracture dislocation complicated by a chronic full thickness retracted rotator cuff tear in an elderly patient. J Orthop Sci. 2016;21(2):237-40.
15. Merolla G, Wagner E, Sperling JW, Paladini P, Fabbri E, Porcellini G. Revision of failed shoulder hemiarthroplasty to reverse total arthroplasty: analysis of 157 revision implants. J Shoulder Elbow Surg. 2018;27(1):75-81.
16. Black EM, Roberts SM, Siegel E, Yannopoulos P, Higgins LD, Warner JJ. Failure after reverse total shoulder arthroplasty: what is the success of component revision? J Shoulder Elbow Surg. 2015;24(12):1908-14.
17. Farshad M, Grogli M, Catanzaro S, Gerber C. Revision of reversed total shoulder arthroplasty: indications and outcome. BMC Musculoskelet Disord. 2012;13:160.
18. Garcia-Fernandez C, Lopiz-Morales Y, Rodriguez A, Lopez-Duran L, Martinez FM. Periprosthetic humeral fractures associated with reverse total shoulder arthroplasty: incidence and management. Int Orthop. 2015;39(10):1965-9.