CLINICAL ARTICLE

Reverse Shoulder Arthroplasty in Patients with Rheumatoid Arthritis: Early Outcomes, Pitfalls, and Challenges

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Objective: To evaluate the early outcomes and risk factors of reverse shoulder arthroplasty (RSA) in patients with rheumatoid arthritis (RA).

Methods: A retrospective study was performed on RA patients who had undergone RSA between January 2016 and January 2018. Preoperative glenohumeral joint damage was evaluated according to two radiographic classification systems. The severity of joint damage was estimated using Larsen's method, while the Levigne-Franceschi method was used to assess the type of destruction. Further, we recorded intra- and postoperative complications. Visual Analogue Scale (VAS) was used to assess the degree of shoulder pain while shoulder function was evaluated with the American Shoulder and Elbow Surgeons (ASES) Shoulder Score. In addition, patients' subjective outcome and range of shoulder motion were recorded. Radiographs were taken and examined during the follow-up period. Paired t-test was used to determine the difference in measurement data between preoperative and the last follow-up. VAS was analyzed using the Wilcoxon matched-pairs signed-rank test.

Results: A total of 14 patients with 14 shoulders were included. All the patients were female with an average age of 60.29 years (range, 49–71 years) at the time of surgery and an average RA disease duration of 24.57 years (range, 5–40 years). Seven of the 14 patients had a history of joint surgery related to RA. Meanwhile, 11 of the 14 shoulders showed glenoid bone defect, and eccentric reaming was performed intraoperatively to avoid base plate malposition. The mean follow-up period for the 14 patients was 2.76 years (range, 2–4 years). The mean VAS decreased from a value of 5.71 ± 1.10 preoperatively to 1.36 ± 0.61 postoperatively ($P < 0.001$). On the contrary, the ASES score showed an increase from 33.93 ± 6.89 to 76.67 ± 5.23 ($P < 0.001$). An increase in active forward elevation, abduction, and external rotation with the arm in 90° of abduction from $85.71° \pm 17.61°$, $77.14° \pm 19.43°$, and $17.14° \pm 10.97°$ to $126.43° \pm 5.23°$, $106.42° \pm 11.72°$, and $38.57° \pm 14.57°$, respectively, was observed ($P < 0.001$). Subjective outcome assessment showed that 13 of the 14 patients were very satisfied or satisfied with the operation, while one patient was uncertain due to co-existing ipsilateral elbow lesion. Notably, one patient acquired a humeral periprosthetic fracture during the operation. In this study, no major complications such as periprosthetic joint infection and dislocation or implant loosening were observed. Further, no patients underwent revision for any reason at the end of the follow-up.

Conclusions: RSA could achieve good early outcomes without high complication rates in patients with RA. Glenoid bone defects and adjacent joints involvement were common in this patient group, which might increase the risk of surgery and affect postoperative satisfaction.

Key words: Clinical outcomes; Reverse shoulder arthroplasty; Rheumatoid arthritis; Risk factor

Introduction

Shoulder involvement is common in patients with rheumatoid arthritis (RA)[1]. In some studies, shoulder symptoms could be found in up to 65%–90% of RA patients, while 45% of the patients presented bilateral shoulder radiological findings 5 years after onset[2]. Similar to the above results, we reported functional impairment and radiological changes at 89.66% and 65.51%, respectively, in a study group in China[3]. However, as a complex and non-weight-bearing joint, shoulder lesions are difficult to be located by clinical examination and are often underdiagnosed in the early stages[2]. Notably, many shoulders of RA patients progress to an advanced stage and arthroplasty should be performed during orthopaedic treatment.

Although anatomic shoulder replacement (including hemiarthroplasty and total shoulder arthroplasty) is effective in pain relief in RA patients[4], long- and mid-term shoulder function are often poor for progressed humeral head upward migration and shoulder motion loss due to rotator cuff dysfunction[5]. On the one hand, RA often leads to rotator cuff dysfunction preoperatively[6, 7]. Severe rotator cuff thinning is common in RA patients due to the synovitis in both glenohumeral joint and subacromial bursa. As a result, rotator cuff involvement, which ranged from thinning to complete tear, could occur in as high as 75% of RA patients[2]. Further, rotator cuff dysfunction progresses in patients who have undergone shoulder arthroplasty. Khan et al.[8] reported that 75% of the patients progressed to rotator cuff dysfunction within 10 years following total shoulder arthroplasty, which ultimately led to shoulder function loss and long-term patient satisfaction decline.

Reverse shoulder arthroplasty (RSA) is an effective treatment for glenohumeral disease with rotator cuff deficiency[9]. Different from traditional anatomic shoulder arthroplasty, RSA changes the biomechanics of the shoulder by increasing implant constraint and repositioning of rotation center. This novel design could increase the deltoid moment arm and recruit more muscle fibers, thus improving forward flexion and abduction function of the shoulder. Despite the differences in design details, the current reverse shoulder prostheses still obey the key principles which were first introduced by Grammont in 1987[10].

To address rotator cuff dysfunction, RSA has been used to treat shoulder destruction associated with RA in recent years. Good clinical outcomes fueled a significant increase in the number of RSA compared with the inevitable decrease of knee and hip arthroplasty utilization in RA patients as a result of revolutionary improvement in medication therapy[11, 12]. In a recent study, Leroux et al.[13] conducted a population-based investigation using Nationwide Inpatient Sample and found a significant increasing trend of utilization of shoulder arthroplasty in RA patients in the United States. Further analysis of arthroplasty types revealed an exponential rise of RSA and a corresponding decrease in anatomic shoulder arthroplasty since 2010.

However, as RA is a relatively rare indication of RSA, most relevant studies are limited by small sample size and short follow-up period[14]. In a systematic review, Cho et al.[12] searched the literature from 1987 to 2014 and only found seven relevant studies, all with small sample that varied from eight to 27 cases. Furthermore, surgical complications such as prosthetic joint infection (PJI) and periprosthetic fracture are more common in RA patients compared with other indications due to poor bone and soft tissue conditions, and use of immunosuppressive drugs[11, 15]. A meta-analysis indicated that the risk of PJI in patients with RA was significantly higher than that in patients with osteoarthritis[16]. Furthermore, Guery et al.[17] reported that two out of eight RA patients acquired PJI following RSA in a long-term study. However, some studies implied varied results. Ekelund et al.[18] reported that the risk of PJI following RSA in RA patients is similar to that of other indications. Bivariate and multivariable logistic regression analyses performed by Morris et al.[19] also showed that RA was not an independent risk factor of infection after RSA. In addition, periprosthetic fracture is another common complication in RA patients due to poor bone quality. Periprosthetic fracture accounted for 44% of total complications in a system review[11], the common fracture sites included scapular spine, acromion, coracoid process, glenoid, humeral shaft, and greater tuberosity.

Therefore, the effectiveness of the RSA procedure in RA patients is in need of further study. Moreover, in China, reverse shoulder arthroplasty was only used recently as an intervention for shoulder involvement in RA patients. To our knowledge, no studies have reported the outcomes of RSA in this patient group.

As a hospital specializing in rheumatoid arthritis treatment, we have been using RSA for the treatment of shoulder involvement in RA patients since 2016. Thus, we designed a retrospective study to investigate the preliminary results of RSA in Chinese RA patients. The aim of this study was to: (i) evaluate the outcomes of RSA in patients with RA in our hospital; (ii) investigate the incidence of postoperative complications; (iii) identify the risk factors and technical difficulties in this patient group.

Materials and Methods

Inclusion and Exclusion Criteria

This study investigated the patients who underwent RSA for rheumatoid arthritis in our hospital between January 2016 and January 2018. Informed consent was obtained from all patients.

The inclusion criteria were established as: (i) patients who met the diagnostic criteria for rheumatoid arthritis; (ii) patients who underwent reverse shoulder arthroplasty; (iii) the pre-and postoperative shoulder measurement results were compared; (iv) clinical and radiological records were complete; (v) the study had a retrospective design.

Exclusion criteria were established as: (i) patients who underwent reverse shoulder arthroplasty for proximal humeral fracture, or had a previous shoulder trauma history; (ii) follow-up time less than 2 years; (iii) incomplete clinical and/or radiological data.

Radiographic Classification

Larsen Score
Joint damage severity was assessed according to the radiographic classification system described by Larsen[20], which is a universal system for use in all synovial joints affected by rheumatoid arthritis. The shoulders were evaluated on a scale of 0 to 5 according to the guideline. A score of 4 and 5 were considered as late stage and joint arthroplasty was recommended.

Levigne–Franceschi Classification
Levigne–Franceschi radiographic classification system[13], which is specific for RA shoulder involvement, was used to evaluate the type of glenohumeral joint damage. According to the criteria, the shoulders were divided into three basic types: C (concentric), A (ascendant), and D (destruction). Further, each type was divided into two subtypes using the criteria: with (1) or without (2) glenoid erosion. Although Levigne–Franceschi radiographic classification system is more complex than Larsen Score, it provides more metrics essential for preoperative plan, including migration direction and bone defect.

Surgical Technique

Anesthesia, Position, and Approach
The patients were placed in beach chair position after general anesthesia, and deltopectoral approach was used. The subscapularis tendon was cut about 1 cm medial to its insertion to expose the glenohumeral joint. In cases where the long head of biceps tendon was intact, the tendon was cut and sutured to the conjoined tendon.

Glenoid Surgical Procedure
The humeral side procedure was performed firstly to fully expose the glenoid. The humeral head was cut at 0° to 30° retroversion using a cutting guide. Removal of labrum, capsule subperiosteal release, use of glenoid retractors were key procedures for glenoid exposure, which was crucial but challenging in RSA. Further, the glenoid was reamed to prepare the bone bed for baseplate. The baseplate was implanted inferiorly on the glenoid to reduce scapular notching, then fixed with three to four screws.

Humeral Side Surgical Procedure
Further, the humeral trial was implanted, and the tension of deltoid was tested. An additional proximal humeral cut was made in cases where the joint was too tight for reduction, while a thicker insert was used when the joint was too loose. Then stem and insert were implanted according to the test result.

Incision Closure
Finally, the incision was closed with suture layer by layer. In case of high soft tissue tension after reduction of the joint, the subscapularis tendon could be partially reattached or not sutured.

Rehabilitation Program
All patients followed the standard postoperative rehabilitation procedure, including shoulder resting in a sling and intermittent passive motion for 4 weeks. Active shoulder forward elevation and abduction was usually allowed at 1 month postoperatively, and resistance exercise was permitted from 3 months after the surgery.

Outcome Measures
All patients received regular follow-up and underwent clinical and radiographic evaluation. Clinical assessment included a range of shoulder active motion (forward flexion, abduction, external rotation with arm in 90° abduction) and clinical scales.

Visual Analogue Scale (VAS)
The VAS is the most commonly used questionnaire for quantification of pain. It is a continuous scale comprised of a horizontal or vertical line, usually 10 cm in length. For pain intensity, the scale is most commonly anchored by "no pain" (score of 0) and "pain as bad as it could be" (score of 10). A score of 0 is considered as no pain, 1–3 mild pain, 4–6 moderate pain, and 7–10 severe pain.

American Shoulder and Elbow Surgeons (ASES) Shoulder Score
The ASES score[21] is commonly used for assessment of should function. This system consists of pain (VAS) and shoulder daily function (including 10 self-evaluation items which are assessed on a 4-point ordinal scale), with a weight of 50% each. The scoring method is as follows: pain score = $(10 - VAS) \times 5$, daily function score = total score of 10 items $\times 5/3$, where ASES score = pain score + daily function score. The maximum ASES score is 100 and a higher score indicates a better shoulder function. The ASES score was evaluated preoperatively and at each follow-up visit postoperatively.

Subjective Outcome
The subjective outcome was applied to evaluate the patients' overall satisfaction with the surgery, which was rated as very satisfied, satisfied, uncertain, and disappointed[13]. The subjective outcome was recorded at the last follow-up.

Radiological Assessment
Radiological assessment included analyzing of radiolucent lines or osteolysis around the implant. Further, scapular
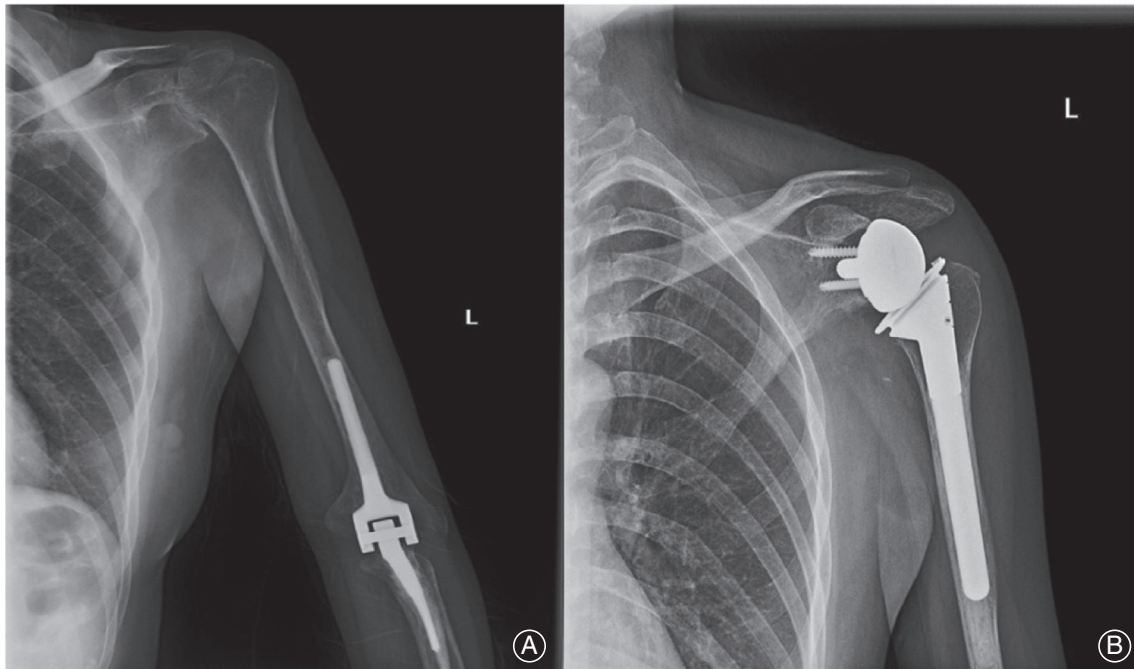
Fig. 1 Plain radiograph of a 49 years old female patient, who underwent ipsilateral total elbow arthroplasty (A) 2 years before the reverse shoulder arthroplasty (B).
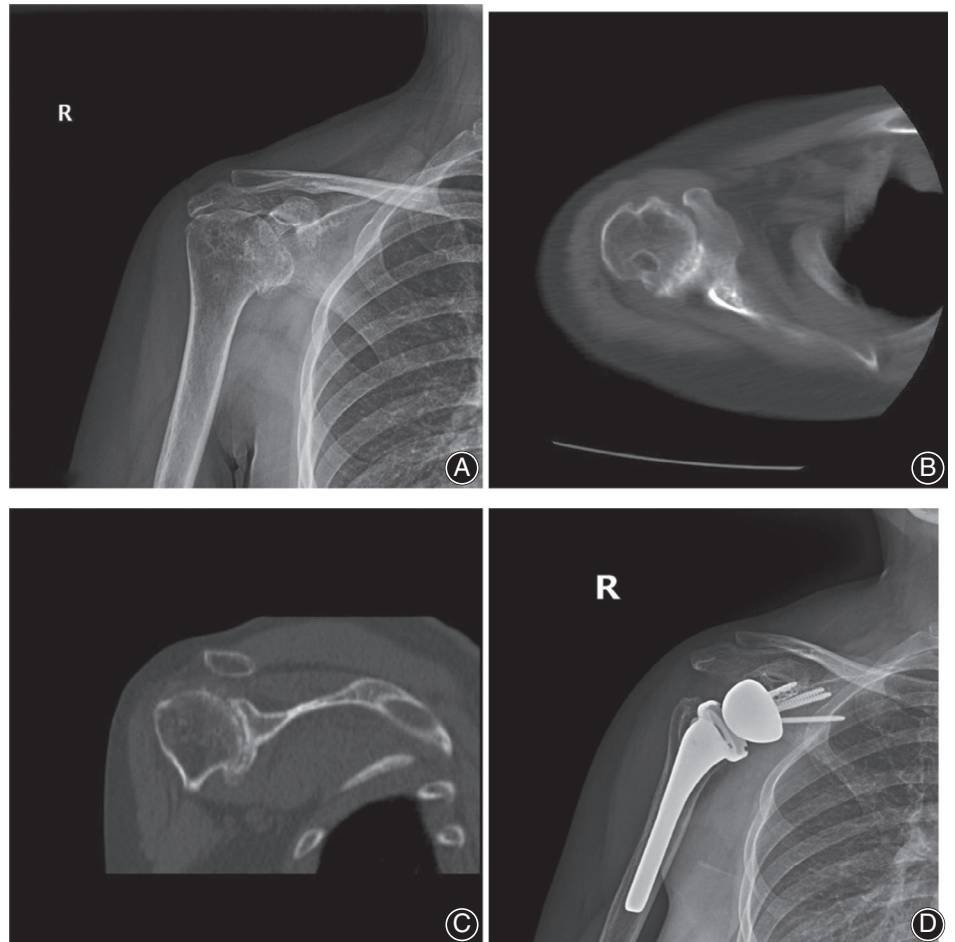

Fig. 2 Plain radiograph and computed tomography scan of a 52 years old female patient, the shoulder was classified as Larsen 4, Levigne-Franceschi A2 (A); axial (B) and coronal (C) two-dimensional computed tomography scan showed remarkable glenoid erosion; eccentric reaming technique was used to prepare the glenoid bone bed, postoperative radiograph (D) showed the base plate implanted in sound position.

notching was determined according to the four-grade classification system introduced by Sirveaux[22]. In this system the classifications are as follows: grade 1: defect limits to the pillar; grade 2: the defect contacts the lower screw of the base plate; grade 3: the defect extends over the lower screw; grade 4: the notch extends under the base plate.

Data Analysis

Data analysis was conducted using SPSS Statistics software (version 24.0, IBM, Armonk, NY, USA). Measurement data were expressed as mean ± standard deviation. Paired *t*-test was used to determine the difference in measurement data between preoperative and last follow-up. VAS was analyzed using the Wilcoxon matched-pairs signed-rank test. $P < 0.05$ was considered statistically significantly.

Results

Demographic Data

A total of 15 patients (15 shoulders) were initially identified from hospital operation registration system according to the inclusion criteria. After excluding one patient who had a history of proximal humeral fracture,14 patients were enrolled for the final study. All operations were performed by three experienced surgeons. The RSA prosthesis used included Comprehensive Reverse Shoulder System (Zimmer, Warsaw, Indiana, USA) in four shoulders and Equnoxe Shoulder Platform System (Exactech, Gainesville, Florida, USA) in 10 shoulders. All the patients were female. The mean age at the time of surgery was 60.29 ± 7.20 years (range, 49–71 years). The average disease duration of rheumatoid arthritis was 24.57 ± 9.41 years (range, 5–40 years). The average follow-up period was 2.76 ± 0.78 years (range, 2–4 years). Seven patients in the study group had a history of joint surgery related to RA, including four arthroscopic shoulder synovectomy, one ipsilateral total elbow replacement (Fig. 1), two total knee arthroplasties, and one total hip arthroplasty.

Preoperative Radiographic Classification

According to Larsen classification, 13 shoulders had a score of 4 and one shoulder had a score of 5 in our study. Meanwhile, one shoulder was classified as C2 (7.14%), two
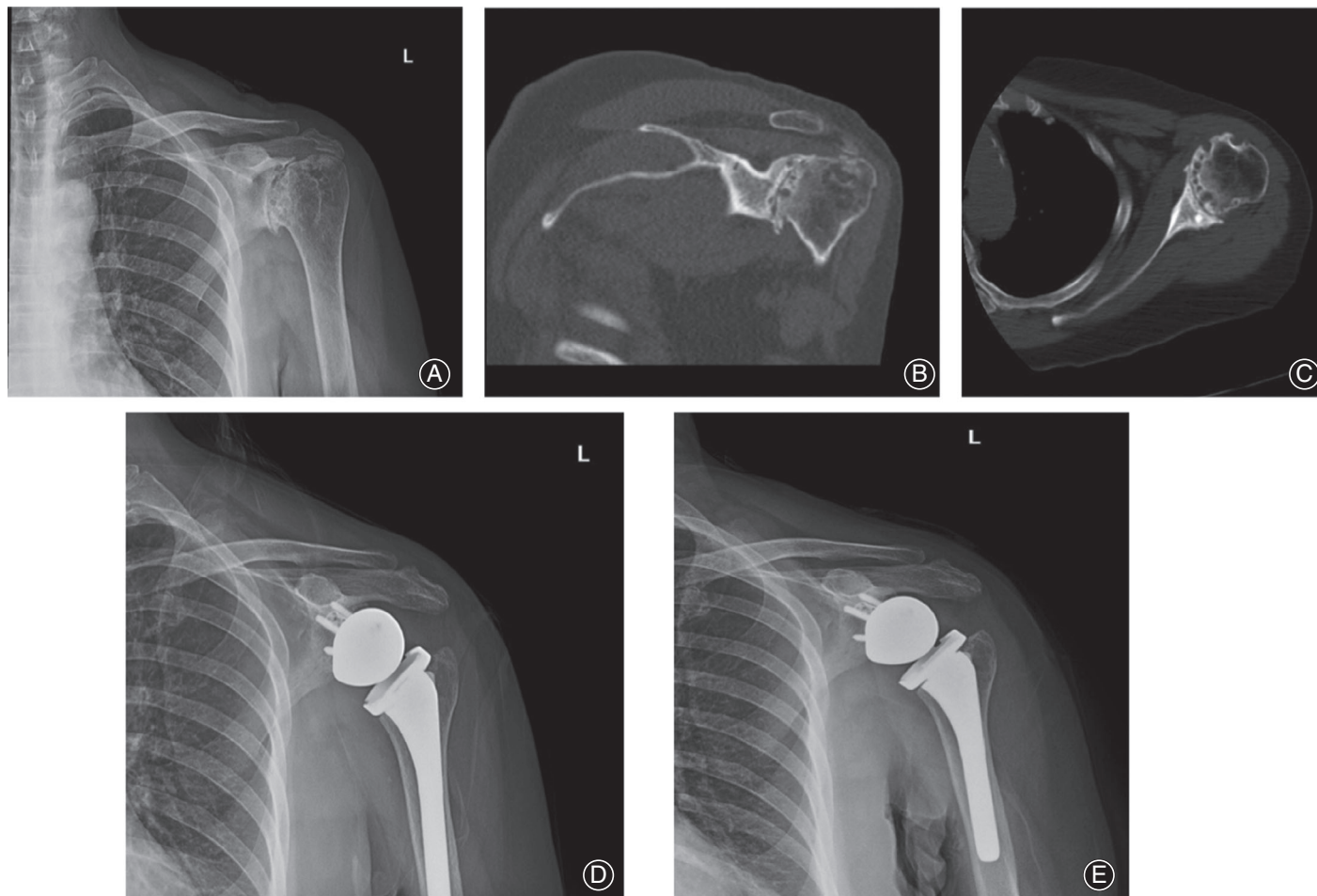
Fig. 3 Plain radiograph and computed tomography scan of a 67 years old female patient, the shoulder was classified as Larsen 5, Levigne-Franceschi D2 (A); axial (B) and coronal (C) two-dimensional computed tomography scan showed remarkable glenoid erosion; eccentric reaming technique was used to prepare the glenoid bone bed, radiographs 1 and 2 years after operation (D, E) showed the base plate implanted in sound position.
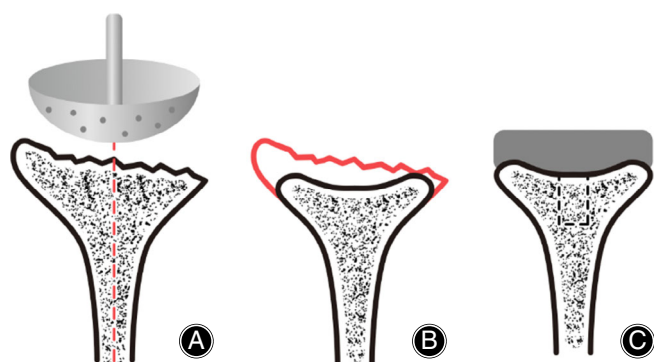
Fig. 4 Diagrams of eccentric reaming technique. Bone defect often resulted in abnormal glenoid version, eccentric reaming was performed to avoid base plate malposition (A); the normal glenoid version was restored (B) and the base plate was implanted (C).

shoulders as A1 (14.29%), seven shoulders as A2 (50%), one shoulder as D1(7.14%), and three shoulders as D2 (21.43%) according to Levigne–Franceschi classification. Type A, which reflected rotator cuff dysfunction and ascending of humeral head, accounted for 64.29% of the total. Eleven shoulders (78.57%) showed glenoid bone defect and were classified as subtype 2 in our study.

Intraoperative Difficulties
Glenoid erosion and deformity were common in RA patients, making it difficult for determination of glenoid center and anteversion (Figs 2, 3). In shoulders with glenoid erosion, eccentric reaming technique was used to avoid malposition of the base plate (Fig. 4). Eleven shoulders with glenoid bone defect were eccentrically reamed and no glenoid bone grafting was performed in our study.

Clinical Outcomes

Change of VAS Score
At the last follow-up, the mean VAS score decreased from 5.71 ± 1.10 points preoperatively to 1.36 ± 0.61 points postoperatively (Z = −3.32, P < 0.001, change percentage [−75.90% ± 12.22%]) (Table 1).

Change of ASES Score
At the last follow-up, the ASES score improved significantly from 33.93 ± 6.89 preoperatively points to 76.67 ± 5.23 points postoperatively (t = −20.56, P < 0.001, change percentage [174.56 ± 51.15]%) (Table 1).

Change of Active Range of Motion
Active range of shoulder motion improved significantly following reverse shoulder arthroplasty. The active forward elevation, abduction, and external rotation with the arm in 90° of abduction increased from 85.71° ± 17.61°, 77.14° ± 19.43°, and 17.14° ± 10.97° preoperatively to 126.43° ± 5.23°, 106.42° ± 11.72°, and 38.57° ± 14.57° at the last follow-up (P < 0.001, Table 1).

Subjective Outcome
Out of the 14 patients, eight were very satisfied while five were satisfied with RSA. One patient was uncertain with the outcome. Further investigation showed that the patient complained of inconvenience in eating and washing due to the concomitant elbow involvement and the limited motion range which was 20°–90°.

Radiographic Results
Radiographic results showed no-evidence of loosening and notching of the inferior aspect of scapular neck at the end of follow-up.

Surgical Site Complications and Reoperations
No severe surgical site complications, such as deep infection, instability, and nerve injury, were recorded in our study. However, one patient intraoperatively acquired a humeral periprosthetic fracture which was fixed with steel wire. The patient rated the outcome as satisfactory and the radiograph at the time of last follow-up showed that the fracture had healed. No reoperation or revision for any reason was noted in our study.

Discussion

Rotator Cuff Involvement in Patients with RA
Rotator cuff dysfunction is a major concern in the selection of RSA in RA patients[2, 6, 7]. In our study, Levigne–Francesch type A, which indicated rotator cuff dysfunction, accounted for 64.29% of the total. However, as a retrospective study, we could not directly evaluate the state of rotator cuff due to

TABLE 1 Results after reverse shoulder arthroplasty					
Variables	Pre-operative	At final follow-up	t value (Z value)	P Value	Change Percentage(%)
VAS	5.71 ± 1.10 (4 − 7)	1.36 ± 0.61 (0 − 2)	−3.32	0.000	−75.90 ± 12.22
ASES	33.93 ± 6.89 (25 − 56.67)	76.67 ± 5.23 (70 − 88.33)	−20.56	0.000	86.60 ± 18.37
Forward elevation (°)	85.71 ± 17.61 (50 ∼ 110)	126.43 ± 5.23 (110 − 150)	−7.28	0.000	55.64 ± 42.77
Abduction (°)	77.14 ± 19.43 (40 − 110)	106.42 ± 11.72 (90 − 130°)	−4.69	0.000	50.59 ± 48.22
External rotation (°°)	17.14 ± 10.97 (10 − 50)	38.57 ± 14.57 (20 − 80°)	−6.87	0.000	174.52 ± 132.50

lack of preoperative magnetic resonance imaging data. Additionally, being a retrospective study without control groups also prevented us from comparing RSA with other treatments, especially anatomic shoulder replacement. Prospective case–control studies may still be necessary to compare these two types of operation, despite the poor long-term outcomes of anatomic shoulder replacement in previous reports[5, 8].

Outcomes of RSA in Patients with RA

As a rare indication, there have been controversial reports whether RSA is beneficial to RA patients as severe bone defect, and poor soft tissue may lead to poor outcome. However, our study demonstrates both satisfactory pain relief and significant shoulder function improvement in this patient group, as 13 of the 14 patients were satisfied or very satisfied with the clinical outcome. In our study, the ASES score was 76.67 which compared favorably with the scores of 73.7 and 72 obtained in previous studies using the same evaluation system[11, 23].

Complications of RSA in Patients with RA

Another major concern is the high complication incidence following RSA, such as PJI and periprosthetic fracture. However, the complication incidence was much lower in our study compared with previous studies[11, 15, 16, 17], with no PJI and only one humeral shaft fracture recorded. Possible causes include: (i) most current studies use small sample size making it difficult to make comparisons between different studies; (ii) the incidence of complications was positively correlated to the surgeon's experience on perioperative management of rheumatoid arthritis[24]. As a hospital specializing in rheumatoid arthritis, our unified perioperative procedures, such as medication adjustment and nursery, may reduce the adverse events.

Pitfalls and Challenges of RSA in Patients with RA

Glenoid bone defect is a significant characteristic of RA shoulder involvement. In our study, 11 out of the 14 shoulders (78.6%) examined had glenoid erosion, similar to the 75% cases reported by Young et al.[13] in patients with RA and much higher than the 37.5% in general etiologies reported by Frankle et al.[25]. Glenoid erosion and deformity makes it difficult to determine the central point and anteversion during operation, thus increasing the risk of base plate malposition that leads to early loosening. Navigation and patient-specific instrumentation may be useful to improve the accuracy of glenoid implant placement[26]. Several techniques, such as structural bone-grafting[27], customized prosthesis[28], and bony increased-offset reverse shoulder arthroplasty [29, 30], have been used in glenoid bone defect treatment with good outcomes. However, as these procedures are complex and prosthesis is not available in our hospital, we treated the glenoid bone loss by eccentric reaming without bone grafting[31], which was simple, device-independent, and time-saving. Notably, 80% host bone bed support should be achieved to guarantee base plate stability when using this method[32].

As a multi-joint involvement disease, concomitant adjacent joints lesions are common in RA patients. This explains why seven of the 14 patients had histories of joint surgery in our study, among which one was total elbow replacement. Furthermore, dysfunction of adjacent joints, especially elbow and wrist, may cause "barrel effect" and result in decline of the overall upper limb function. The patient who was uncertain with the outcome of RSA in our study had elbow dysfunction. Therefore, introduction of upper extremity function assessment systems, such as Disabilities of the Arm, Shoulder, and Hand questionnaire[33], may be helpful for preoperative plan and follow-up evaluation.

Limitations

There were several limitations in our study. First, the sample size was small thus the findings were not conclusive. However, as RA is an uncommon indication of RSA, our series of 14 shoulders is a medium-sized series compared with other studies. Secondly, the follow-up time of the present study was only 2.76 years, thus long-term outcomes, such as loosening, revision rates, and scapular notching, could not be obtained in the current study. Further prospective designed studies with large sample size are required to investigate the long-term efficacy of RSA in patients with RA.

Conclusions

In summary, our study showed that RSA achieved good short-term outcomes without high incidence of complications in patients with RA. Glenoid bone loss and adjacent joints involvement were common in this patient group, which might have increased the difficulty of operation and decreased postoperative satisfaction. Therefore, comprehensive preoperative upper extremity examination, fine preoperative planning, and careful operation handling are essential for favorable outcomes of the procedure.

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EARLY OUTCOMES OF RSA IN PATIENTS WITH RA

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