



Clinical comparison of humeral-lateralization reverse total shoulder arthroplasty between patients with irreparable rotator cuff tear and patients with cuff tear arthropathy

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ARTICLE INFO

Keywords:

Reverse total shoulder arthroplasty
massive rotator cuff tear
irreparable rotator cuff tear
cuff tear arthropathy
humeral-lateralization
pseudoparalysis

Level of evidence: Level III, Retrospective Cohort Comparison, Treatment Study

Background: This study aimed to compare the clinical and radiologic outcomes between patients with irreparable cuff tears (ICTs) and those with cuff tear arthropathy (CTA) after reverse total shoulder arthroplasty (RTSA) with a humeral-lateralization prosthesis.

Methods: A total of 127 patients with ICTs and CTA who underwent RTSA were enrolled and matched at a 1:2 ratio by propensity score. Preoperative shoulder function was assessed for all patients. Radiologic parameters including the acromion–deltoid tuberosity (ADT) distance, lateral humeral offset, and scapular notching were evaluated.

Results: Thirty-four patients in the ICT group and 68 patients in the CTA group were matched for comparison. Preoperatively, mean active forward flexion in the ICT group ($89.7^\circ \pm 29.4^\circ$) was significantly better than that in the CTA group ($65.5^\circ \pm 24.0^\circ$, $P < .001$). In the CTA group, fatty infiltration of the supraspinatus was worse (3.7 ± 0.5) and the ADT distance was shorter (134.0 ± 12.0 mm) compared with the ICT group preoperatively (3.3 ± 0.8 [$P = .008$] and 140.7 ± 12.5 mm [$P = .001$], respectively). There was no significant difference in postoperative functional or radiologic outcomes between the 2 groups. However, gains in active forward flexion (37.9° in ICT group vs. 61.5° in CTA group, $P < .01$) and abduction (42.1° in ICT group vs. 60.6° in CTA group, $P < .01$) were significantly greater in the CTA group than in the ICT group.

Conclusions: Shoulder function was significantly improved after RTSA regardless of the preoperative diagnosis. Postoperatively, radiologic findings were not significantly different between the 2 groups. Due to the fact that preoperative range of motion and rotator cuff status were better in patients with ICTs, improvements in active forward flexion and abduction were significantly greater in patients with CTA.

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This study was performed at the Department of Orthopaedic Surgery, Ewha Womans University Seoul Hospital, Seoul, Republic of Korea.

Approval for this study was received from the Ewha Womans University Mokdong Hospital Institutional Review Board (EUMC 2018-06-037-001). This study was carried out in accordance with the ethical standards in the 1964 Declaration of Helsinki and the relevant regulations of the US Health Insurance Portability and Accountability Act.

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<https://doi.org/10.1016/j.jseint.2020.03.001>

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Reverse total shoulder arthroplasty (RTSA) was originally designed to improve upper-extremity elevation and provide pain relief in patients with rotator cuff deficiency combined with glenohumeral arthritis.¹⁶ Since the development of RTSA, many clinical studies have proved that RTSA is an effective treatment for cuff tear arthropathy (CTA) with reduced range of motion (ROM) in the shoulder joint.³⁴ Gradually, the indications for RTSA have expanded to other shoulder conditions, including irreparable cuff tears (ICTs), that were previously treated using different methods.²⁰ To treat an ICT that has not progressed to CTA, there are various joint-preserving surgical options, including allograft, tendon transfer, and superior capsular reconstruction, with proven clinical

results.^{4,5} However, RTSA is preferred, especially in elderly patients with ICTs, because it is associated with reliable improvements in both shoulder pain and function.² Although both ICTs and CTA commonly demonstrate significant rotator cuff deficiency, CTA is associated with more extensive shoulder pathology represented by superior migration of the humeral head and arthritis of the glenohumeral joint.⁴¹ Considering the mechanism of RTSA, which alters kinematics and moves the joint axis into the replaced fulcrum, the differences between ICTs and CTA potentially correspond to the radiologic and clinical outcomes of RTSA. Previous studies have analyzed the clinical outcomes after RTSA based on preoperative shoulder diseases using various implant designs.^{29,32,36,42}

Among the various types of RTSA implants, lateralization of the humeral or glenoid component is currently used to minimize the complications associated with traditional medialized RTSA, including scapular notching and limitations in external and internal rotation.¹⁹ Biomechanically, lateralization of the glenoid component may decrease scapular notching and impingement of shoulder motion, and lateralization of the humeral component can preserve a more anatomic position of the greater tuberosity of the humerus and enhance compressive forces by increasing the abductor lever arm and deltoid wrapping.^{30,43} Therefore, a direct comparison of the clinical outcomes of RTSA with a humeral-lateralization design between CTA with an altered humeral position and an ICT with preserved anatomic alignment might provide reliable information for determining the difference in the effectiveness of RTSA for both diseases.

This study aimed to compare clinical and radiologic outcomes between patients with CTA and those with ICTs after RTSA using a prosthesis design with lateralization of the humeral component. Our hypothesis was that the degree of improvement and the clinical outcomes of RTSA might be different between patients with CTA and those with ICTs because CTA is associated with more extensive rotator cuff degeneration and deterioration of joint alignment.

Materials and methods

Patient selection

This retrospective, comparative, multicenter study included a total of 136 patients who underwent RTSA with the same prosthesis for ICTs or CTA between September 2015 and December 2017. The inclusion criteria were patients aged 65–85 years who underwent primary RTSA for ICTs or CTA and were followed up and evaluated clinically for up to 2 years postoperatively. Regarding the ICT group, we defined ICTs in this study as irreparable conditions including completely torn supraspinatus and infraspinatus tendons confirmed in the anteroposterior dimension on sagittal T2 magnetic resonance imaging (MRI) with tear retraction to the glenoid or beyond on T2 coronal MRI, as well as superior migration of the humeral head that met grade 1 or 2 in the Hamada classification (proximal migration of the humeral head with an acromiohumeral interval < 5 mm without glenohumeral arthritis and acetabularization).^{6,17} Patients in the CTA group were identified following the definition of CTA, which manifests as rotator cuff deficiency, superior migration of the humeral head resulting in a decreased acromion–deltoid tuberosity (ADT) distance, the presence of joint space narrowing and osteophytes in the glenohumeral joint, rounding of the greater tuberosity of the proximal humerus, and acetabularization of the undersurface of the acromion on preoperative anteroposterior shoulder radiographs or MRI.⁷ The exclusion criteria were (1) previous surgery for a proximal humeral or acromial fracture of the affected shoulder, (2) erosion or bone

defects of the glenoid requiring bone graft or metal block, (3) concomitant systemic neuromuscular disease including Parkinson disease, (4) primary osteoarthritis or rheumatoid arthritis, and (5) avascular necrosis of the proximal humerus. Of 136 enrolled patients, 9 patients were excluded after application of the exclusion criteria (2 had proximal humeral fractures, 1 received additional bone graft for glenoid erosion, 2 had Parkinson disease and cerebellar atrophy, 2 had rotator cuff tears with primary glenohumeral osteoarthritis without proximal migration of the humeral head, 1 had rheumatoid arthritis, and 1 had avascular necrosis of the humeral head); finally, 127 patients met the inclusion criteria. The study group was assigned based on the preoperative diagnosis.

Propensity score matching

To minimize selection bias from patient-related factors, which have been revealed to affect the outcomes of CTA or ICTs in RTSA, multiple factors, including patients' age, sex, and body mass index (BMI), were considered.^{1,9,11,22,27,31,37} Propensity score (PS) matching was used to obtain reliable information by considering factors known to affect the clinical outcomes of RTSA. PS matching at a 1:2 ratio was performed based on the patients' age, sex, and BMI through logistic regression.

Assessment of clinical outcomes

The clinical outcomes of all patients were assessed preoperatively and at 24 months postoperatively using the visual analog scale score for shoulder pain, American Shoulder and Elbow Surgeons shoulder score, Constant score, and ROM in the affected shoulder, including active forward flexion and abduction in the scapular plane, external rotation with the elbow at the side, and internal rotation (Table 1). Internal rotation was quantified by the level of the spine reached with the thumb. The vertebral level of the rotation was counted as follows: 1–7 for the first to seventh cervical vertebra, 8–19 for the first to twelfth thoracic vertebra, 20–24 for the first to fifth lumbar vertebra, 25 for the sacrum, and 26 for the buttock. Pseudoparalysis was defined as the inability to achieve shoulder forward flexion > 90° despite full passive flexion.^{3,40} Two physician assistants who were blinded to the group assignments at each hospital investigated shoulder function and active ROM.

Radiologic evaluation

Radiographs were evaluated using digital tools in a picture archiving and communication system. Radiologic assessments included standard true anteroposterior and axial radiographs with the arm placed in neutral rotation. By use of preoperative radiographs of the affected shoulder, the ADT distance, center-of-rotation (COR) distance, and lateral humeral offset (LHO) were determined following methods described in previous studies^{22,44,45} (Fig. 1).

The preoperative status of the subscapularis on shoulder MRI was evaluated using the Lafosse classification.²⁶ To facilitate comparative analysis, type I and II lesions were classified as partial ruptures whereas lesions of type III or higher were regarded as complete ruptures. The degree of fatty muscle degeneration of the supraspinatus and infraspinatus on preoperative MRI was described following the Goutallier classification, which assigns grades depending on the infiltration of the supraspinatus and infraspinatus muscles on T1 sagittal images: grade 0, no fatty infiltration; grade 1, some streaks of fat; grade 2, more muscle than fat; grade 3, as much muscle as fat; or grade 4, less muscle than fat.¹⁵

Table 1
Comparison of preoperative patient data and functional status between ICT and CTA groups by propensity score matching

	ICT group (n = 34)	CTA group (n = 68)	P value
Age at operation, yr	73.5 ± 4.1	75.1 ± 4.3	.067
Sex, male/female, n	6/28	9/59	.376
BMI, kg/m ²	23.5 ± 2.9	24.5 ± 3.2	.110
Side concordant with dominant arm/not concordant with arm, n	27/7	53/15	.540
Duration of follow-up, mo	33.2 ± 7.3	31.3 ± 6.9	.188
Pseudoparalysis, n (%)	20 (59)	54 (79)	.026*
Preoperative functional assessment			
VAS score	6.8 ± 1.3	7.2 ± 1.7	.215
ASES score	42.9 ± 9.3	38.7 ± 7.3	.016*
Constant score	43.4 ± 17.5	34.9 ± 15.2	.013*
Preoperative range of motion			
Active forward flexion, °	89.7 ± 29.4	65.5 ± 24.0	<.01*
Abduction, °	81.6 ± 29.3	59.2 ± 18.8	<.01*
External rotation, °	30.4 ± 17.2	24.9 ± 12.2	.064
Internal rotation, level of spine [†]	21.8 ± 3.2	22.8 ± 3.0	.117

ICT, irreparable cuff tear; CTA, cuff tear arthropathy; BMI, body mass index; VAS, visual analog scale; ASES, American Shoulder and Elbow Surgeons.

Data are expressed as mean ± standard deviation unless otherwise indicated.

* A statistically significant difference was noted.

[†] The spinal level of internal rotation was numbered as follows: 1–7 for the first to seventh cervical vertebra, 8–19 for the first to twelfth thoracic vertebra, 20–24 for the first to fifth lumbar vertebra, 25 for the sacral vertebra, and 26 for the buttock.

For postoperative radiographs taken at the final follow-up visit, inferior overhang of the glenosphere, version of glenosphere (the angle measured between the line drawn along the central peg and the perpendicular line of axis along the body of the scapula on an axial radiograph), glenosphere–scapular neck angle, scapular notching, ADT distance, COR distance, and LHO were estimated. Inferior scapular notching was rated using the Sirveaux classification (grade 1, defect contained within the pillar of glenoid; grade 2, defect confluent with the inferior-most screw; grade 3, defect localized above the inferior-most screw; or grade 4, defect involving the central post) on anteroposterior radiographs, and cases classified as grade 2 or higher were counted as having scapular notching in this study.³⁹

Radiologic measurements were performed by 2 orthopedic surgery fellows. Two weeks after the measurements by these 2 surgeons, 1 surgeon performed the radiographic examinations again to allow assessment of intraobserver reliability. Intraobserver and interobserver measurement reliabilities were analyzed using the intraclass correlation coefficient (ICC). ICCs were calculated via a 2-way mixed-effects model for absolute agreement between the measurements of each observer. An ICC value ≥ 0.75 was considered to reflect excellent reliability.²⁴

Surgical techniques

The patient was placed in the beach-chair position under general anesthesia, and a deltopectoral approach was used. RTSA was performed with the same prosthesis (Equinox; Exactech, Gainesville, FL) in all patients. The subscapularis tendon was detached from the lesser tuberosity, and 2 nonabsorbable sutures were placed in the tendinous portion. After tenotomy of the long head of the biceps, soft tissue tenodesis was performed at the upper margin of the pectoralis major insertion and the remnant tissues of the supraspinatus and infraspinatus tendons were completely resected in both groups. The humeral head was cut in 20° of retroversion, and the glenoid was reamed in approximately 10° of inferior tilt. After the glenoid baseplate was implanted, 4 peripheral screws were inserted. The humeral component was placed in 20° of retroversion after the glenoid component was placed. Suitable tension could be adjusted after template reduction using the trial component. All patients underwent subscapularis tendon repair with a transosseous suture when possible. All surgical procedures were performed with the same technique by 4 orthopedic surgeons at 4 participating institutions.

Postoperative rehabilitation

The same protocol for postoperative rehabilitation was applied in all patients. Patients underwent shoulder immobilization supported by an arm sling for the first 4 weeks, and pendulum exercises were allowed after the first postoperative day. Self-assisted exercise was encouraged after discontinuation of the 4 weeks of immobilization, and self-assisted active exercise was started 6

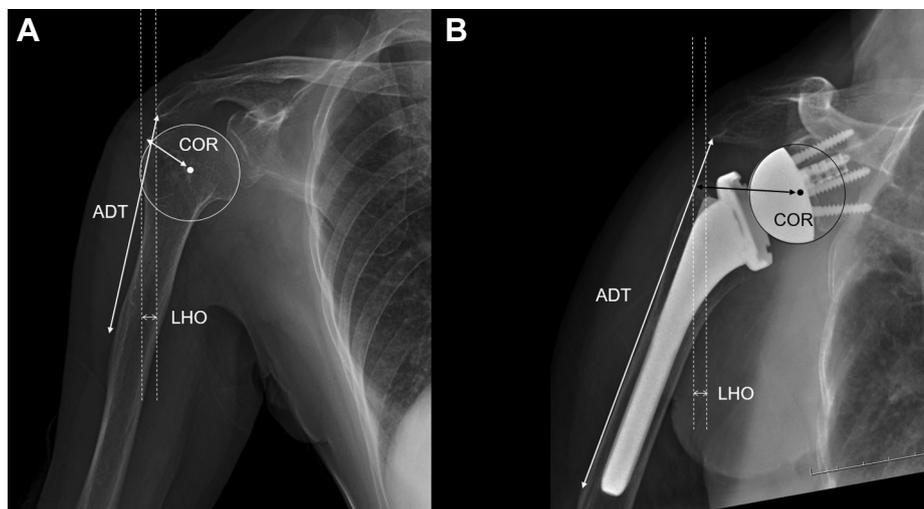


Figure 1 Radiologic measurements of acromion–deltoid tuberosity (ADT) distance, center-of-rotation (COR) distance, and lateral humeral offset (LHO) on preoperative (A) and postoperative (B) shoulder anteroposterior radiographs. The ADT distance is the distance from the inferolateral acromion tip to the apex of the deltoid tuberosity. The COR is drawn at the center of a circle that completely fits around the humeral head preoperatively (A) and glenosphere postoperatively (B). Then, the COR distance is determined as the length from the most prominent superolateral margin of the greater tuberosity to the COR. LHO is the distance between the line perpendicular to the horizontal line on the radiograph that abuts the lateral tip of the acromion and the line perpendicular to the most prominent margin of the greater tuberosity.

weeks after surgery. Shoulder muscle-strengthening exercises with elastic bands were started at 8 postoperative weeks. Daily living activities and light labor were allowed after 3 postoperative months.

Statistical analysis

Independent *t* tests and paired *t* tests were used to evaluate the differences in functional outcomes and ROM between groups both preoperatively and postoperatively. The other nonparametric variables were processed by χ^2 analysis and the Fisher exact test. PS calculation and group matching were performed based on multiple regression analysis. All statistical analyses were performed using SPSS software (version 21.0; IBM, Armonk, NY, USA), and *P* < .05 indicated statistical significance.

Results

Preoperative demographic characteristics

Of 102 patients after PS matching, 34 had an ICT whereas 68 had CTA. Before PS matching, the incidence of pseudoparalysis in the CTA group was significantly higher than that in the ICT group (*P* = .036); there were no statistically significant differences according to sex, BMI, dominant arm, or duration of follow-up. After PS matching, in each group, 34 patients in the ICT group and 68 patients in the CTA group were matched for the analysis, and all patient-related factors, as described, were statistically equivalent. No significant difference in the ratio of subscapularis reattachment during RTSA was found between the 2 groups (13 of 34 shoulders in the ICT group [38.2%] vs. 30 of 68 in the CTA group [44.1%], *P* = .363).

Clinical outcomes

On preoperative assessments in all patients, mean American Shoulder and Elbow Surgeons and Constant scores, active forward flexion, and abduction were better in the ICT group than in the CTA group (Table I). The postoperative comparison showed no significant difference in functional results and ROM between the 2 groups (Table II). In terms of the amount of improvement after surgery, the CTA group was significantly improved in terms of active forward flexion (61.5° ± 30.3°, *P* < .01) and abduction (60.6° ± 22.2°, *P* < .01) (Table III). Other functional outcomes and ROM measures showed similar amounts of change between the 2 groups. In the CTA group, there was 1 patient with a postoperative complication who was clinically observed for low-grade infection (1.5%). This patient underwent revision surgery with prosthesis removal and antibiotic-loaded cement insertion at 15 months postoperatively.

Radiologic outcomes

The incidence of subscapularis tendon rupture beyond type II in the CTA group was significantly higher than that in the ICT group (Table IV). Additionally, muscle fatty degeneration of the supraspinatus and infraspinatus tendons was significantly higher in the CTA group than in the ICT group. In terms of anatomic alignment, the mean preoperative ADT distance in the CTA group was significantly shorter than that in the ICT group. The postoperative radiographs showed no significant difference in the ADT distance, COR distance, LHO, or glenoid component positioning, such as inferior overhang, version, and glenosphere–scapular neck angle (Table V). The presence of inferior scapular notching rated grade 2 or higher was also not statistically different between the 2 groups.³⁹ The reliability of radiologic evaluation was identified, with excellent ICC values reflecting interobserver and interobserver

Table II
Comparison of postoperative functional outcomes between ICT and CTA groups

	ICT group (n = 34)	CTA group (n = 68)	<i>P</i> value
Postoperative functional assessment			
VAS score	1.8 ± 1.4	2.0 ± 1.6	.528
ASES score	73.7 ± 7.5	72.5 ± 6.9	.419
Constant score	64.7 ± 8.5	63.6 ± 9.3	.553
Postoperative range of motion			
Active forward flexion, °	125.3 ± 18.6	121.9 ± 15.2	.329
Abduction, °	123.7 ± 19.0	119.7 ± 19.3	.327
External rotation, °	42.5 ± 14.2	38.4 ± 11.8	.126
Internal rotation, level of spine*	22.1 ± 2.2	22.7 ± 2.0	.181

ICT, irreparable cuff tear; CTA, cuff tear arthropathy; VAS, visual analog scale; ASES, American Shoulder and Elbow Surgeons.

Data are expressed as mean ± standard deviation.

* The spinal level of internal rotation was numbered as follows: 1–7 for the first to seventh cervical vertebra, 8–19 for the first to twelfth thoracic vertebra, 20–24 for the first to fifth lumbar vertebra, 25 for the sacral vertebra, and 26 for the buttock.

concordance (preoperative measurement, 0.90–0.96; postoperative measurement, 0.84–0.91).

Discussion

Patients who underwent RTSA for CTA demonstrated comparable clinical outcomes and radiologic parameters to ICT patients despite a preoperatively inferior functional status and more extensive rotator cuff degeneration. In particular, RTSA yielded greater improvement in shoulder forward flexion and abduction for CTA than for ICTs.

Massive rotator cuff tears can progress to CTA in certain patients owing to the role of basic calcium phosphate crystals.⁷ Calcium crystals derived from cartilage fragmentation are regarded to aggravate enzymatic responses and destruction of remaining cuff tendons and articular cartilage, although this remains debatable.^{7,21} In addition to biological reactions during disease progression, anatomic alteration of the glenohumeral joint and glenohumeral arthritis are considered the most important factors that distinguish CTA from ICTs. Hamada et al¹⁷ suggested 5 radiographic grades of massive cuff tears and outlined possible pathogenic mechanisms in response to progressive radiographic changes, during the period of conservative treatment, from massive rotator cuff tears to CTA. Although CTA presents dislocation or rupture of the long head of the biceps and weakness in active forward flexion and external rotation as characteristic findings, there is a lack of information

Table III
Comparison of preoperative to postoperative changes in functional outcomes

	ICT group (n = 34)	CTA group (n = 68)	<i>P</i> value
Functional assessment			
VAS score	−4.7 ± 2.3	−5.1 ± 2.6	.470
ASES score	30.8 ± 13.3	34.0 ± 9.6	.217
Constant score	21.3 ± 19.6	27.5 ± 17.2	.102
Range of motion			
Active forward flexion, °	37.9 ± 23.2	61.5 ± 30.3	<.01*
Abduction, °	42.1 ± 21.6	60.6 ± 22.2	<.01*
External rotation, °	11.2 ± 9.1	14.7 ± 12.5	.145
Internal rotation, level of spine†	0.2 ± 1.3	−0.2 ± 2.1	.310

ICT, irreparable cuff tear; CTA, cuff tear arthropathy; VAS, visual analog scale; ASES, American Shoulder and Elbow Surgeons.

Data are expressed as mean ± standard deviation.

* A statistically significant difference was noted.

† The spinal level of internal rotation was numbered as follows: 1–7 for the first to seventh cervical vertebra, 8–19 for the first to twelfth thoracic vertebra, 20–24 for the first to fifth lumbar vertebra, 25 for the sacral vertebra, and 26 for the buttock.

Table IV

Comparison of preoperative data of radiographic assessments between ICT and CTA groups

	ICT group (n = 34)	CTA group (n = 68)	P value
Subscapularis, partial/complete, n*	27/7	41/27	.042 [‡]
Fatty infiltration of supraspinatus [†]	3.3 ± 0.8	3.7 ± 0.5	.001 [‡]
Fatty infiltration of infraspinatus [†]	2.8 ± 1.0	3.5 ± 0.6	<.001 [‡]
Acromion-deltoid distance, mm	140.7 ± 12.5	134.0 ± 12.0	.010 [‡]
Center-of-rotation distance, mm	20.3 ± 3.5	19.4 ± 5.1	.355
Lateral humeral offset, mm	13.6 ± 4.7	14.8 ± 5.1	.267

ICT, irreparable cuff tear; CTA, cuff tear arthropathy.

Data are expressed as mean ± standard deviation unless otherwise indicated.

* The structural integrity of the subscapularis was assessed by preoperative magnetic resonance imaging and categorized following the Lafosse classification: partial tear for Lafosse type I or II and complete tear for Lafosse type III or IV.

[†] The degree of fatty infiltration was graded and expressed as a number using the Goutallier classification.[‡] A statistically significant difference was noted.

comparing clinical and radiologic rotator cuff status between CTA and ICTs.⁷ Our study noted more extensive fatty infiltration of the rotator cuff and poor active forward flexion in CTA patients compared with ICT patients. Furthermore, significant differences were found in terms of pseudoparalysis and shoulder forward flexion and abduction. These results are consistent with previously described characteristic symptoms and findings of CTA, which suggest that preoperative shoulder function and cuff quality in CTA were inferior to those in ICTs.^{7,17}

Despite poorer preoperative forward flexion and a poorer rotator cuff status in patients with CTA, our study demonstrated similar clinical outcomes after RTSA regardless of preoperative etiology. Comparable outcomes between CTA and ICTs after RTSA were reported despite the subtle effects of demographic factors, such as age and sex.³⁵ However, Lindbloom et al²⁸ indicated that male patients with massive rotator cuff tears without osteoarthritis had lower satisfaction levels than patients with CTA after RTSA. Factors including age, sex, smoking, and BMI are known to be related to the magnitude of clinical improvement after RTSA.^{9,11,27,31,37} On the basis of the effect of obesity on the clinical outcomes of RTSA, increased body weight was significantly associated with deep infection after RTSA.¹ In our study, the overwhelming female majority made it difficult to identify negative effects on male patients. Furthermore, because both groups had a mean age ≥ 70 years, the age of the patients included in this study was presumed to contribute to the similar results for postoperative ROM and clinical findings.

Our study showed no significant gain in internal rotation after RTSA. Although ICTs had a better status of the subscapularis tendon than that of CTA preoperatively, the final internal rotation ROM values in the 2 groups were similar. These results are supported by other clinical studies demonstrating that internal rotation is affected by the angle of retroversion in humeral cutting, size and position of the glenoid component, and prosthesis design.²⁵ Moreover, comparison of clinical outcomes according to subscapularis repair in RTSA showed that the unrepaired group had a better range of abduction and external rotation without instability.¹² To evaluate functional recovery after RTSA, active forward flexion has been emphasized to be a key factor providing patient satisfaction and maintenance of activities of daily living.^{8,22,38} However, in addition to active forward flexion, internal rotation and external rotation play important roles and are known to be contributing factors to postoperative satisfaction after RTSA.²³ Therefore, it seems that there was no difference in clinical results between the 2 groups in our study regardless of the preoperative status of the subscapularis tendon or tendon repair.

Table V

Comparison of postoperative data of radiographic assessments between ICT and CTA groups

	ICT group (n = 34)	CTA group (n = 68)	P value
Inferior overhang of glenosphere, mm	3.7 ± 1.4	3.4 ± 1.2	.081
Version of glenosphere, °	98.3 ± 11.2	99.1 ± 9.8	.809
Glenosphere–scapular neck angle, °	95.3 ± 8.5	97.5 ± 7.4	.251
Scapular notching, n (%) [*]	3 (8.8)	9 (13.2)	.383
Acromion-deltoid distance, mm	154.3 ± 14.2	157.6 ± 12.8	.120
Center-of-rotation distance, mm	43.5 ± 4.1	42.3 ± 4.7	.192
Lateral humeral offset, mm	10.5 ± 4.5	11.9 ± 4.5	.212

ICT, irreparable cuff tear; CTA, cuff tear arthropathy.

Data are expressed as mean ± standard deviation unless otherwise indicated.

* Scapular notching was counted in case of grade 2 or higher according to the classification system of Sirveaux et al.³⁹

The lateralization design of RTSA has been advanced to minimize possible inferior scapular notching and glenohumeral instability, as well as to improve shoulder movement, which have been pointed out as major limitations of the medialized design.¹⁸ Humeral component lateralization has been presented as a promising parameter to increase the deltoid muscle force for shoulder abduction and to decrease joint forces during abduction in a biomechanical experiment.¹⁴ Franceschetti et al¹⁰ compared clinical outcomes of RTSA with a lateralized COR vs. RTSA with humeral lateralization for CTA and identified no significant difference in clinical and radiologic outcomes; however, humeral lateralization in patients older than 65 years yielded a positive trend for all ROM parameters. Despite similar clinical results among the different designs of prosthesis, a lower incidence of inferior scapular notching is considered an important marker of the effectiveness of humeral-lateralization RTSA compared with a conventional medialized prosthesis within 5 years postoperatively.¹³ The prevalence of scapular notching in this study was similar to that found in another study, which reported that 10.1% of RTSAs were associated with scapular notching by use of the same prosthesis after ≥2 years' follow-up.³³ However, in a different study, in a comparison of clinical outcomes after long-term observation of RTSA vs. those at a mid-term point, the survival rates and clinical results at the long-term evaluation were significantly decreased compared with those at the mid-term evaluation.² Gerber et al¹³ demonstrated that 47% of enrolled patients had grade 3 or 4 inferior scapular notching with progression of the quantity and degree of notching over time. Therefore, long-term research to investigate the clinical outcomes of RTSA according to the preoperative status and aging is required to observe changes in inferior scapular notching from RTSA with a lateralized prosthesis.

This study had several limitations. First, the study enrolled a small number of patients, and the follow-up period was relatively short. Because of the recent release of the prosthesis used in this study, the number of patients enrolled was small, and consequently, there might be a high possibility of a type II error because of low statistical power derived from the small sample size. However, the use of a single lateralized prosthesis makes it possible to compare the results with other designs of prosthesis and to minimize bias due to differences in prostheses.^{28,32} Additionally, we tried to overcome these weaknesses through PS matching. Second, this study was conducted as a retrospective study that did not control for various factors. Prospective studies would provide more reliable results through proactive control of the various factors affecting the results of RTSA. Prospective studies particularly would be expected to be able to identify the final outcomes according to the preoperative pseudoparalysis level, as well as the status of the rotator cuff and deltoid muscle. Third, multicenter studies have

inherent drawbacks, including the subtle differences between procedures at the different sites.

Conclusion

Shoulder pain and function were significantly improved after RTSA with a humeral-lateralization prosthesis in both patients with ICTs and those with CTA. Although preoperative active forward flexion and rotator cuff degeneration were worse in CTA patients, functional outcomes and ROM were equivalent between the groups at 2 years postoperatively. The degree of improvement in active forward flexion and abduction was significantly greater in patients with CTA. Postoperative measurements using radiologic parameters were similar, and a lower rate of inferior scapular notching was noted. Even though RTSA provided satisfactory results for ICTs, it is considered a more effective treatment for CTA.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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