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Long-term outcomes of hemiarthroplasty using a smaller head combined with rotator cuff reconstruction in patients with cuff-tear arthropathy

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A R T I C L E I N F O

Keywords:
Hemiarthroplasty
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Younger patients
Glenoid wear

Level of evidence: Level IV; Case Series; Treatment Study

Background: Hemiarthroplasty (HHR) using a smaller head with rotator cuff reconstruction is a treatment option for cuff-tear arthropathy, offering advantages like facilitating rotator cuff-tear closure, increasing the lever arm of deltoid, and restoring function in irreparable cuff tears. This study aimed to evaluate the long-term outcomes of this procedure.

Methods: A retrospective analysis was conducted for 91 shoulders undergoing HHR using a smaller head with rotator cuff reconstruction between May 2005 and September 2012. Surgery involved reducing the size of humeral head and performing rotator cuff reconstruction based on the site of the deficient rotator cuff. The study analyzed University of California, Los Angeles shoulder scores, Japanese Orthopaedics Association shoulder scores, range of motion, and postoperative radiographs.

Results: Twenty-eight patients, divided into an elderly group (14 women, 2 men, mean age 74.5 ± 3.8 years) and a younger group (6 women, 6 men, mean age 63.5 ± 3.1 years) were followed up for a mean of 133.2 ± 14.1 months. No complications were reported. The clinical scores and range of motion significantly improved postoperatively and remained over 10 years. Radiographs revealed high incidence of glenoid wear (82.1%), bone resorption (43%) and cranial humeral head migration (54%), with no prosthesis loosening.

Conclusion: We believe that HHR using a smaller head with rotator cuff reconstruction is a surgical technique that can maintain stable long-term outcomes in both elderly and younger individuals with cuff-tear arthropathy.

Cuff-tear arthropathy (CTA), as defined by Neer in 1983 is a disease characterized by several distinct features: massive rotator cuff tear, collapse of the humeral head, upward migration of the head, and erosion of the acromion, acromioclavicular joint and coracoid process.[19] Additionally, the diameter of the humeral head affected by CTA has been revealed to be typically larger than that of the unaffected side due to thickening of the cartilage layer on the humeral head.[24]

Patients commonly experience chronic and intense pain, along with a significant limitation in active range of motion (ROM). They may also exhibit weakness in abduction and external rotation.

The surgical management of CTA is challenging. In recent decades, reverse total shoulder arthroplasty (RSA) has increasingly been used as the primary treatment option for CTA.[3,23] This option certainly provides pain relief and improves functional outcomes, but still presents numerous issues, such as a high complication rate.[8,27]

Shoulder hemiarthroplasty (HHR) has been performed as one of the treatment options for CTA. However, problems such as insufficient improvement in shoulder function have been recognized.[6,22,28] The procedure of HHR alone is unable to restore or

Ethical approval for this study was obtained from the institutional review board of Hokushin Orthopaedic Hospital (study no.1803) and all patients agreed to participate in this study.

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compensate for shoulder function, therefore, adequate postoperative shoulder function cannot be expected. Furthermore, the available reports on the long-term outcomes of HHR for CTA are limited.

To address the problems of HHR, we have applied a strategy using a smaller head HHR combined with rotator cuff reconstruction for CTA since 2001.[25] Although we have reported favorable short-term outcomes of this procedure for young patients with CTA,[18,25] the long-term outcomes remain unknown.

The aim of this study was to present the long-term outcomes of smaller head shoulder HHR combined with rotator cuff reconstruction in patients with CTA.

Methods

A retrospective analysis was conducted on a series of patients with CTA who underwent primary HHR using a smaller head combined with rotator cuff reconstruction at our institution and related facilities between May 2005 and September 2012. The general indication for these procedures was severe pain and compromised shoulder function in patients with CTA identified as Hamada classification grade 3 or higher, as well as an irreparable rotator cuff tear accompanied by fatty infiltration graded as Goutallier classification grade 3 or 4 in radiological assessments.

Exclusion criteria included CTA with shoulder instability with antero-superior migration of the humeral head. During the study period, a total of 91 shoulders (90 patients) that had undergone HHR using a smaller head combined with rotator cuff reconstruction for CTA were identified. There were 4 shoulders (3 patients) that had undergone revision surgery to TSA due to the progression of glenoid wear at 25,26, 27, and 56 months postoperatively, and these 4 shoulders were excluded. Twenty-eight shoulders were successfully followed up for over 10 years, while the remaining cases were lost to follow-up analysis within the 10-year period due to various reasons, including death, health-related issues, and loss of contact.

Surgical technique

All surgical procedures were performed with the patient in the beach chair position under general anesthesia. The superior deltoid splitting approach was employed for all patients. In specific situations where there was a subscapularis tendon tear requiring pectoralis major transfer, the delto-pectoral approach was also adopted.

In 8 cases, the axillary approach was added for latissimus dorsi and teres major muscle transfers. The coracoacromial ligament and acromial bony spur were preserved. Among the procedures, 27 surgeries used the Global Advantage Shoulder System (Depuy Mitek; Raynham, MA, USA), while 1 surgery used the Bigliani/Flatow Shoulder System (Zimmer Biomet, Warsaw, IN, USA). All prostheses were press-fit and positioned in 40° of retroversion (greater than the normal level of retroversion) to prevent anterosuperior escape of the humeral head. A humeral head prosthesis one size smaller and thinner than the resected original humeral head size was basically selected to aid rotator cuff reconstruction. Opting for a humeral head that is excessively undersized may result in glenohumeral joint instability. The final determination of the humeral head size is made by ensuring that the greater tuberosity is not too high, covering the osteotomy surface of the humeral neck, and achieving joint stability in the anterior-posterior and inferior directions. In terms of anterior-posterior instability, when manually translating the humeral head posteriorly, it should ride up on the posterior rim of the glenoid and return when released. For inferior stability, when pulling the upper arm downward, the humeral head's upper border should be lowered to approximately the height of the glenoid upper edge, which is confirmed under fluoroscopy.

Table I
The Japanese Orthopaedic Association (JOA) score (100 points).

I pain (30 points)					
None	30				
Minor pain during sports or heavy labor	25				
Mild pain during work	20				
Mild pain during daily living	15				
Moderate tolerable pain	10				
Severe pain	5				
Unable to engage in any activiity due to pain	0				
II Function (20 points)					
Strength in abduction		Endurance (Duration of holding a 1 kg dumbbell)			
Normal	5	>10 s	5		
Excellent	4	>3 s	3		
Good	3	<2 s	1		
Fair	2	unable	0		
Poor	1				
Zero	0				
Activities in daily living					
Tying hair	1,0.5,0	Able to reach opposite armpit	1,0.5,0		
Tying belt in back	1,0.5,0	Able to open and close sliding doors.	1,0.5,0		
Able to reach to mouth by hand	1,0.5,0	Able to reach items on overhead shielves	1,0.5,0		
Able to sleep with the affected side down	1,0.5,0	Able to wipe the buttocks	1,0.5,0		
Able to get items from the pocket of a jacket	1,0.5,0	Able to put on a jacket	1,0.5,0		
III Active range of motion (30 points)					
Elevation		External rotation		Internal rotation	
>150°	15	>60°	9	>Th 12 spinous process	6
>120°	12	>30°	6	>L5 spinous process	4
>90°	9	>0°	3	Buttock	2
>60°	6	>−20°	1	Below buttock	0
>30°	3	<−20°	0		
0°	0				
IV Radiographic evaluation (5 points)					
Normal	5				
Moderate change or subluxation	3				
Severe change or dislocation	0				
V Joint stability (15 points)					
Normal	15				
Slight instability or apprehension	10				
Severe instability or subluxation	5				
Dislocation	0				

Appropriate procedures for rotator cuff reconstruction were performed based on the location of the irreparable cuff tear, aiming to address each specific dysfunction accordingly.

For cases with an irreparable tear of the supraspinatus and infraspinatus tendons with an intact subscapularis and teres minor, partial transfer of subscapularis, a modified procedure based on Cofield's technique[4] was employed. In such cases, two-thirds of the superior aspect of the subscapularis tendon was transferred superiorly and sutured to the greater tubercle, as well as the teres minor tendon and the stumps of the supraspinatus or infraspinatus

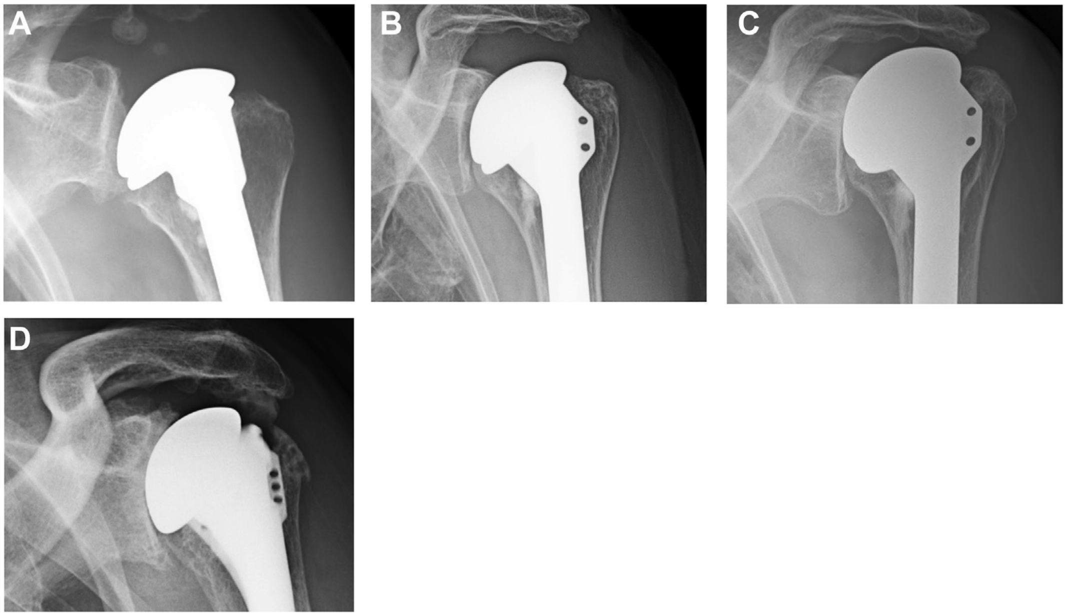

Figure 1 Modified Goya's Classification of glenoid wear. (**A**). Grade 0: No significant postoperative changes compared to the preoperative glenoid. (**B**). Grade 1: Postoperative glenohumeral joint space narrows than due to glenoid cartilage wear, with no contact between the glenoid and humeral head prosthesis. (**C**). Grade 2: Contact between the glenoid and humeral head prosthesis without glenoid erosion. (**D**). Grade 3: Glenoid erosion, further classified into 3 subtypes: 3A: Partial erosion of the anterior glenoid. 3B: Partial erosion of the superior glenoid. 3C: Concentric glenoid erosion.

tendons. If a posterosuperior rotator cuff deficiency involving the infraspinatus and teres minor was present, latissimus dorsi and teres major muscles transfers were performed. The latissimus dorsi and teres major muscles were transferred to the middle to inferior facet of the grater tuberosity, following the Herzberg technique,[12] to effectively reconstruct external rotation. In cases of an anterosuperior irreparable tear involving the supraspinatus and subscapularis tendons, with intact teres minor tendon, a pectoralis major muscle transfer was performed.

Postoperative treatment

An abduction pillow was used for 8 weeks following the surgery. Passive ROM exercises commenced at 4 weeks postoperatively, with antigravity active ROM exercises permitted from 10 weeks postoperatively.

Clinical and radiographic evaluation

The presence of intraoperative and postoperative complications was investigated. All patients were assessed using The University of California, Los Angeles shoulder score (UCLA score), the Japanese Orthopaedics Association score (JOA score), and measurements of shoulder ROM (active flexion, external rotation and internal rotation). The JOA score sheet, which is a 100-point evaluation system for assessing shoulder function, evaluates pain, activities of daily living, ROM, muscle strength and degenerative changes and stability observed on x-ray images (Table I).

The anteroposterior and axillary views of plain radiographs were analyzed to classify all patients using Seebauer classification preoperatively. Following the classification, the patients in class IIB were excluded from this study. Additionally, postoperative radiographs were used to evaluate glenoid wear, prosthesis loosening, bone resorption around the humeral stem and cranial migration of the humeral head, both immediately after surgery and at final follow-up.

Glenoid wear was evaluated using the modified Goya's classification,[10,15,16] which grades the extent of glenoid wear from grade 0 to grade 3 (Fig. 1). Grade 3 is further divides into 3 subtypes based on the site of erosion. Prosthesis loosening was defined as the presence of periprosthetic radiolucency greater than 2 mm in thickness.

Bone resorption around the prosthesis was evaluated using Inoue's classification,[14] which grades the degree of bone resorption from grade 0 to grade 4 (Fig. 2). In this study, patients with grade 4 bone resorption at the latest follow-up were defined as having the presence of bone resorption around the prosthesis. The cranial migration of the humeral head was determined by comparing its position at the follow-up periods with that immediately after surgery using the Oizumi classification.[20]

Statistical analysis

Preoperative and postoperative data were compared using a paired t-tests and repeated measures single factor Analysis of Variance (ANOVA) for all patients. Further, postoperative data were analyzed according to patient age using a paired *t*-test, chi-square test for independence, and Fisher's exact probability test. The patients were divided into 2 groups, aged 70 and above, and under 70. The clinical scores and ROM in these 2 groups were compared using an unpaired *t*-test, Mann–Whitney's U test. The Significance was determined at a threshold value of $P < .05$.

Results

Participants

Twenty-eight patients (20 women, 8 men) were available for the follow-up assessments for a period of 10 years or more. Mean duration of follow-up at the latest assessment was 133.2 ± 14.1 months. The mean age of the patients at the time of surgery was 69.8 years (range, 59-82 years).

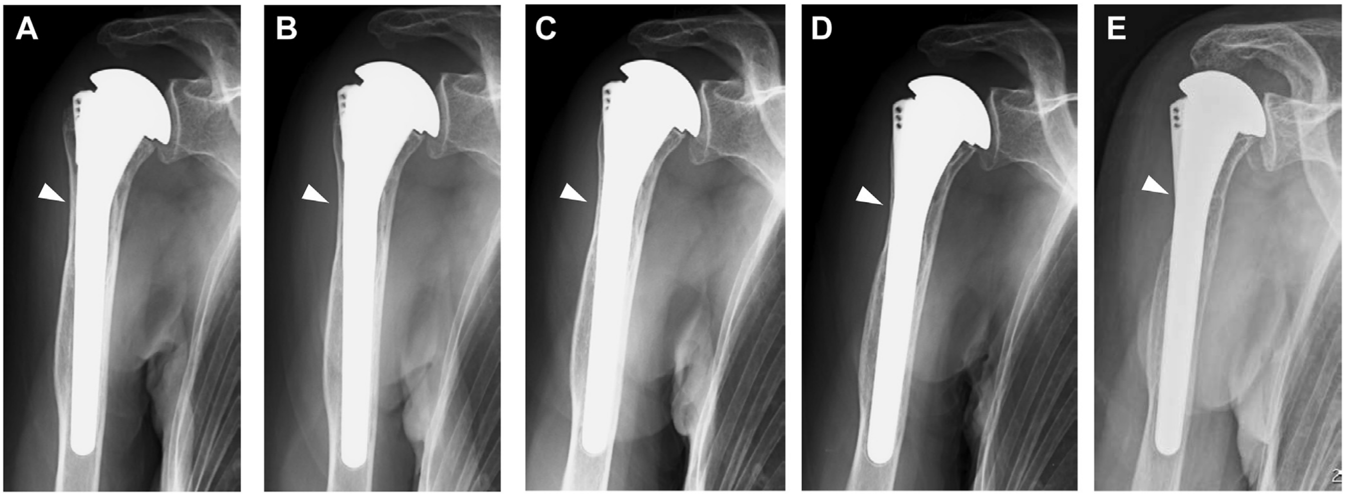

Figure 2 Inoue's classification of bone resorption. (**A**). Grade 0: No bone resorption. (**B**). Grade 1: Decrease in the cortical bone density. (**C**). Grade 2: Thinning of the cortical bone comprising less than half of the original thickness. (**D**). Grade 3: Thinning of the cortical bone comprising more than half of the original thickness. (**E**). Grade 4: Complete disappearance of the cortical bone.

Table II
Characteristics of included patients.

	Elderly group (n = 16)	Younger group (n = 12)
Sex		
men	2	6
women	14	6
Age of the surgery (y)	74.5 ± 3.8	63.5 ± 3.1
Length of follow-up (mo)	133.6 (120-159)	133.8 (120-177)
Previous surgery	2 (1 ARCR, 1 ORCR)	0
Rotator cuff reconstruction (no. of patients)		
Partial SSC tendon transfer	12	7
LD and TM muscle transfer and partial SSC tendon transfer	3	5
PM muscle transfer	1	0

ARCR, arthroscopic rotator cuff repair; *ORCR*, open rotator cuff repair; *SSC*, subscapularis; *LD*, latissimus dorsi; *TM*, teres major; *PM*, pectlaris major.

Among these patients, there were 16 individuals (14 women, 2 men) who were 70 years old or over at the time of surgery, constituting the elderly group. Mean age was 74.5 ± 3.8 years. In addition, 12 patients (6 women and 6 men) were younger than 70 years, comprising the younger group. Mean age was 63.5 ± 3.1 years.

In the elderly group, two patients had experienced previous surgeries on the shoulder before undergoing the smaller head HHR combined with cuff reconstruction: 1 patient had undergone arthroscopic rotator cuff repair and the other patient had undergone open rotator cuff repair.

As the rotator cuff reconstruction, 19 patients (68%) underwent partial subscapularis tendon transfer, 8 patients (29%) underwent partial subscapularis tendon transfer and latissimus dorsi and teres major muscles transfers, and 1 patient (3%) underwent pectoralis major muscle transfer. Participants' data are listed in Table II.

Clinical assessment

No patients experienced intraoperative or postoperative complications or required secondary surgeries in this series.

Mean UCLA score improved significantly from 10.4 ± 3.6 preoperatively to 27.0 ± 5.8 at the latest follow-up in the elderly group ($P < .001$) and from 11.3 ± 3.0 to 27.7 ± 4.6 in the younger group($P < .001$). The mean JOA score also significantly improved from 47.2 ± 15.9 preoperatively to 76.8 ± 11.4 at the latest follow-up in the elderly group ($P < .001$) and from 44.1 ± 14.1 to 79.5 ± 11.5 in the younger group ($P < .001$). Thirteen patients (7 in the elderly group and 6 in the younger group) of pseudoparalysis with preoperative active flexion less than 90° were included in this study. The average flexion in the short-term postoperative period (mean of 17.1 ± 6.4 months) was 140 ± 29.2° for the elderly group and 146.7 ± 18.9° for the younger group, both of which showed significant improvement compared to the preoperative values ($P = .003$ and $P = .001$). The external rotation angle was 26.3 ± 19.3° for the elderly group and 32.1 ± 17.3° for the younger group, with the younger group showing significant improvement from the preoperative values ($P < .001$), while the elderly group remained unchanged ($P = .2$). When comparing the short-term, mid-term (mean of 78.9 ± 17.9 months postoperatively), and long-term (as per this study) outcomes, there were no significant differences in the external rotation for the elderly group and the flexion and external rotation for the younger group. The flexion for the elderly group had significantly decreased in the mid-term and long-term outcomes compared to the short-term outcomes, but the significant improvement observed from the preoperative values was still maintained. The internal rotation angles were assessed using the JOA internal rotation score (Table I). In the elderly group, while the latest follow-up scores were significantly higher compared to the preoperative internal rotation scores, there was no difference in scores between the elderly group during the short term and mid-term periods and the scores of the younger group when compared to their respective preoperative scores. Mean postoperative UCLA score, JOA score, and ROM did not differ significantly between elderly group and younger groups. The clinical assessment data are presented in Table III.

Radiologic assessment

According to the preoperative Seebauer classification, 14 patients were class IA, 10 patients were class IB, 4 patients were class IIA, and no patients class IIB.

Table III
Clinical assessment.

	Elderly group (n = 16)	Younger group (n = 12)	*P* Value
Clinical score			
UCLA score (points)			
Preoperative	10.4 ± 3.6	11.3 ± 3.0	.52
At the latest follow-up	27.0 ± 5.8	27.7 ± 4.6	.87
P value	<.001	<.001	
JOA score (points)			
Preoperative	47.2 ± 15.9	44.1 ± 14.1	.64
At the latest follow-up	76.8 ± 11.4	79.7 ± 11.5	.71
P value	<.001	<.001	
Range of motion			
Flexion (°)			
Preoperative	87.3 ± 38.3	87.1 ± 44.6	.75
Short term	140 ± 29.2	146.7 ± 18.9	.53
Mid-term	126.3 ± 29.5	140.5 ± 17.1	.18
At the latest follow-up	133.6 ± 32.0	140.8 ± 22.3	.45
P value (preoperative vs. the latest)	.002	.004	
External rotation (°)			
Preoperative	22.9 ± 20.4	7.1 ± 17.8	.06
Short term	26.3 ± 19.3	32.1 ± 17.3	.46
Mid-term	26.3 ± 11.3	27.7 ± 19.3	.83
At the latest follow-up	22.8 ± 17.8	26.7 ± 19.3	.79
P value (preoperative vs. the latest)	.69	.002	
Internal rotation (JOA score)			
Preoperative	3.4 ± 1.6	3.8 ± 1.7	.56
Short term	4.0 ± 0.9	4.0 ± 1.2	1.0
Mid-term	4.1 ± 1.1	4.2 ± 1.3	.92
At the latest follow-up	4.4 ± 1.6	3.8 ± 1.3	.25
P value (preoperative vs. the latest)	.02	1.0	

UCLA score, The University of California, Los Angeles shoulder score; *JOA score*, The Japanese Orthopaedics Association score.

Table IV
Radiologic assessment.

Radiological findings	Elderly group (n = 16)	Younger group (n = 12)	
Preoperative Seebauer classification	No of patients	No of patients	*P* value
IA	5 (31%)	9 (75%)	
IB	9 (56%)	1 (8%)	
IIA	2 (13%)	2 (17%)	
IIB	0	0	
Elderly group vs. younger group			.08
Postoperative change			
Grade 3 glenoid wear (modified Goya's classification)			
Short term	0	0	
Mid-term	2 (13%)	2 (17%)	.4
Long term	4 (25%)	8 (67%)	.03
Bone resorption (Grade 4 of Inoue classification)			
Short term	0	0	
Mid-term	2 (13%)	0	.55
Long term	5 (31%)	3 (25%)	.72
Cranial migration of humeral head			
Short term	4 (25%)	3 (25%)	.94
Mid-term	9 (56%)	6 (50%)	1.0
Long term	10 (63%)	6 (50%)	.51

No patients showed loosening of the prosthesis at the latest follow-up. Glenoid wear was observed in 23 patients (82%) at latest follow-up. All patients in the younger group showed glenoid wear. Grade 3 glenoid wear was absent in both groups in the short term, but in the mid-term, 2 patients were observed in each group. Grade 3 glenoid wear was observed in 12 patients, with grade 3A in 1 in the younger group, grade 3B in 2 in the elderly group and 4 in the younger group, and grade 3C in 2 patients in the elderly group and 3 in the younger group. Significant differences were observed only in the long-term follow-up between the 2 groups regarding grade 3 glenoid wear ($P = .03$).

As for grade 4 of Inoue classification bone resorption, there were no patients in either group in the short-term. In the mid-term, 2 patients were seen in each group. In the long term, there were 5 patients in the elderly group and 3 in the younger group, indicating an increasing trend over time.

Regarding the cranial migration of the humeral head, a progression in the Oizumi classification grade compared to immediately after surgery was observed the following pattern: in elderly group, there were 4 patients in the short term, 9 in the mid-term and 10 in the long term. In the younger group, there were 3 patients in the short term, 6 in the mid-term, and long term.

Patients who exhibited radiological changes such as grade 3 glenoid wear, bone resorption, and cranial migration of humeral head at the latest follow-up were compared to patients without these changes in terms of UCLA score, JOA score, and ROM. Among the patients with cranial migration of the humeral head, significant decreases were observed in UCLA score and flexion compared to those without cranial migration ($P = .03$ and $P = .03$, respectively). There was no statistical correlation between grade 3 glenoid wear or bone resorption and clinical scores. The radiographic assessment data are presented in Table IV.

In Fig. 3, the case images of a patient who underwent HHR using a smaller head combined with rotator cuff reconstruction for CTA are presented. The preoperative images, as well as those at 1.5 years and 13 years postoperatively, along with the shoulder joint ROM at 13 years postoperatively, as shown. Although the clinical scores and ROM at 13 years postoperatively are satisfactory, we observed grade 3C glenoid wear and grade 4 bone resorption.

Discussion

Limited reports have been made regarding the long-term outcomes of HHR for CTA.

Sanchez-Sotelo reported on the 5-year outcomes of HHR with partial rotator cuff repair for patients with CTA.[21] In the latest follow-up, the successful rate was 67%, and mean forward elevation measured 91°. Gadea, et al demonstrated the outcomes of HHR for patients with CTA, compared to patients with glenohumeral arthritis, rheumatoid arthritis, avascular necrosis, and fracture sequelae, with a mean follow-up of 141.9 months.[7] That study indicated that HHR for CTA resulted in the worst functional outcomes compared to patients with other diagnoses, along with a low prosthesis survival rate. In comparison, Goldberg, et al demonstrated favorable results in a study of 25 shoulders with CTA or a massive rotator cuff tear with glenohumeral arthritis.[9] That investigation had a mean follow-up period of 10 years (range, 4-16 years). Notably, no instances of shoulder revision due to issues such as implant failure, loosening, infection, or fracture were observed. That study showed that in patients with an intact coracoacromial arch who were able to raise their arm ≥90° before surgery, HHR and rotator cuff repair can be reliable procedures. Furthermore, they demonstrated a trend toward improved outcomes when comparing patients with complete coverage at the time of cuff repair to those who only underwent partial rotator cuff repair. Performing cuff repair in conjunction with HHR may be crucial for improving shoulder function after the surgery. However, in patients with CTA,

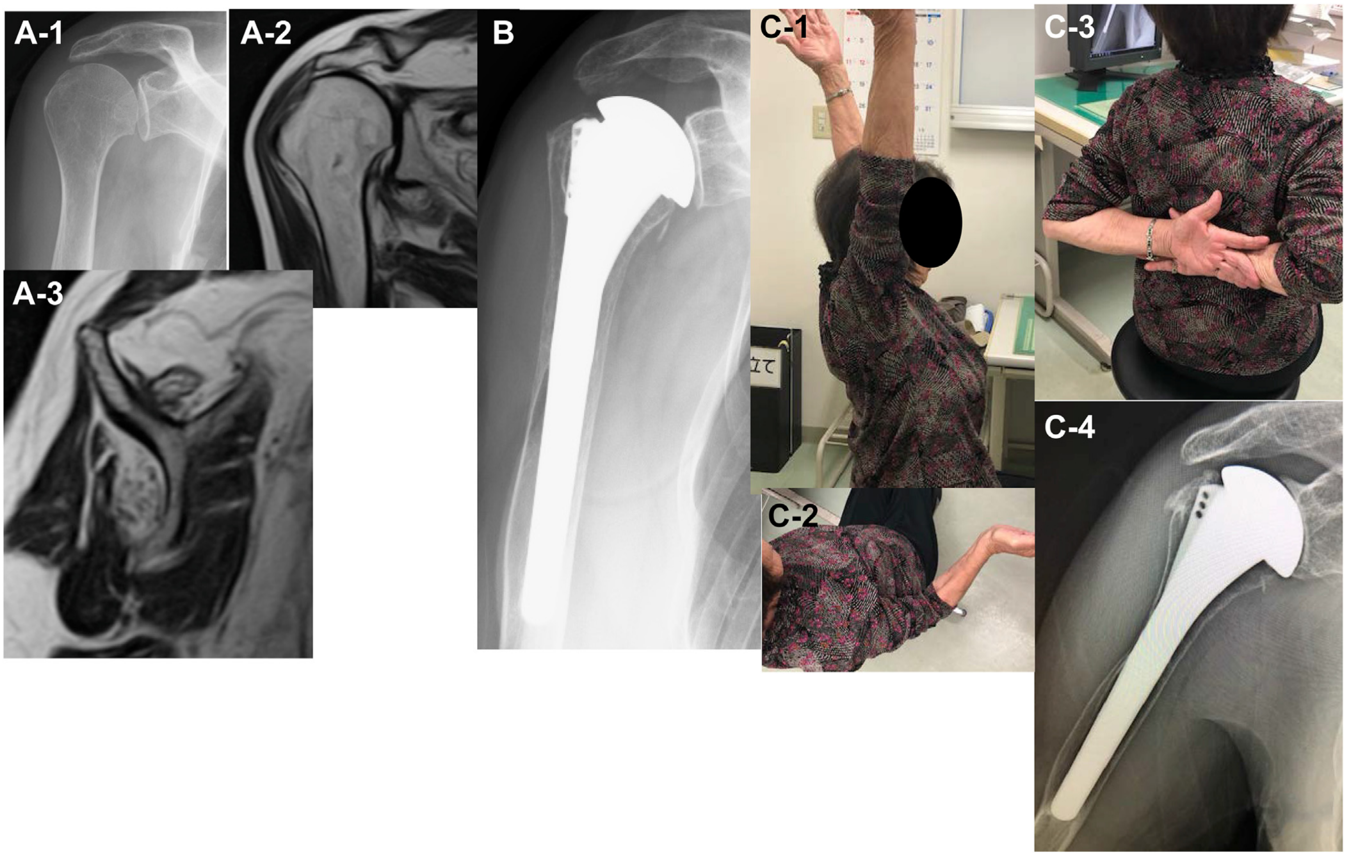

Figure 3 A female patient with CTA who was 76 years old at the time of surgery. HHR with a smaller head with partial subscapularis transfer and latissimus dorsi and teres major muscle transfer was performed. (**A**1-3): preoperative X-ray and magnetic resonance imaging image. (**B**): X-ray image 1.5 years postoperatively. (**C**1-4): Thirteen years postoperative ROM and X-ray image. The JOA score was 94 points and UCLA score was 34 points. The X-ray revealed grade 3C glenoid wear and grade 4 bone resorption. *CTA*, cuff-tear arthropathy; *HHR*, hemiarthroplasty; *ROM*, range of motion; *JOA*, Japanese Orthopaedics Association score; *UCLA*, University of California, Los Angeles shoulder score.

it is often challenging to repair the rotator cuff. Therefore, reconstructing its function becomes necessary.

We have been performing smaller head HHR combined with rotator cuff reconstruction as a treatment for CTA since 2001, with the aim of improving shoulder function. This approach offers several advantages in managing CTA.[25] The diameter of the humeral head affected by CTA typically becomes larger than that of the unaffected side.[24] Therefore, it is reasonable to select a humeral head prosthesis smaller than the size of the resected original head. This reduced size of the humeral head then facilitates closure of the cuff defect using tendon transfers. This change also shifts the center of rotation of the glenohumeral joint medially, thereby increasing the lever arm of the deltoid muscle. Additionally, this reduction in humeral head size creates a mismatch with the glenoid, promoting a wider ROM for the shoulder. To prevent the humeral head from escaping in the anterosuperior direction, a greater retroversion angle is employed when installing the prosthesis than the normal angle. Furthermore, incorporating tendon or muscle transfers based on the location of the irreparable rotator cuff tear, such as partial subscapularis tendon transfer, latissimus dorsi and teres major muscle transfer, and pectoralis major muscle transfer, in conjunction with HHR helps to restore postoperative shoulder function. It provides good external rotation, whereas RSA results in limited postoperative external rotation.[3]

In the current study, HHR using a smaller head combined with rotator cuff reconstruction has been shown to provide long-term pain relief, satisfactory shoulder function, and no loosening of the prosthesis over a 10-year follow-up period in both elderly and younger groups. Postoperative clinical scores and ROM did not differ significantly between groups in this series. This suggests that this approach is effective not only for younger patients but also for elderly individuals. In the radiological assessment, while no instances of prosthesis loosening were observed, a high rate of specific radiological changes was noted. Glenoid wear was the most prevalent, present in 82.1% of cases. Grade 3 changes indicating glenoid erosion were observed in 52.2% of patients with glenoid wear. Notably, the rate of grade 3 glenoid wear was significantly higher in the younger group compared to the elderly group. This finding supports the suggestion made by Persons et al that glenoid cartilage erosion can be expected after HHR in young, active individuals with an intact rotator cuff,[21] consistent with findings for the younger group in the current study. The potential causes for this glenoid wear progression have been suggested to involve changes in the articular conformity and changes in muscle moment arms, altered loading conditions after HHR may contribute to the development of tensile and sheer forces at the implant-cartilage interface. This may accelerate cartilage degeneration on the glenoid side. Younger individuals, with greater muscular strength and high activity levels than elderly individuals, are believed to experience more frequent and advanced glenoid wear due to the elevated stress imposed on the glenoid.

While these patients experienced pain relief and favorable shoulder function over an extended period, careful monitoring of the progression of glenoid wear is crucial. In addition, a high rate of bone resorption was seen around the prosthesis and cranial migration of the humeral head was observed. Patients with cranial migration of the humeral head exhibited significantly lower clinical scores and flexion compared to those without. This suggests that cranial migration of the humeral head may indicate insufficiency of the reconstructed rotator cuff. Grade 3B glenoid erosion may also be related to cuff insufficiency. Closely monitoring progression of these radiological changes is therefore important.

In recent decades, RSA has gained popularity as a primary treatment option for CTA and irreparable massive rotator cuff tear. Several reports have compared the outcomes between RSA and HHR for CTA. Leung et al conducted a study demonstrating that RSA outperformed HHR in terms of pain relief, shoulder function, and active elevation during a minimum follow-up period of 2 years.[17] Both procedures had a similar complication rate of 25%. Similarly, Barlow et al reported that RSA provided greater pain relief and superior functional outcomes, compared to HHR in patients with CTA.[1] However, in both reports, only repair of the subscapularis tendon was performed if possible, as this structure had been released during the approach to the joint. Other rotator cuff repairs or reconstructions were not performed. This could have potentially resulted in reduced postoperative shoulder function in patients undergoing HHR.

Regarding the long-term outcomes of RSA, Gerber et al reported 16-year results following RSA for patients with rotator cuff dysfunction, including CTA.[8] While the postoperative clinical outcomes exhibited significant improvement, the complication rate reached 59%, and the survivor rate without RSA failure was 84% at 15 years. Bassens et al also showed the good long-term outcomes from RSA and a high survivor rate (97.4% after 8 years).[2] However, they noted a trend toward declining functional outcomes after more than 5 years postoperatively. Similarly, Favard et al reported on the results of RSA with a minimum follow-up of 9 years.[5] They observed a survival rate of 89% after 10 years and a progressive deterioration in patient function after the eighth year. Such reports indicate a deterioration in functional outcomes beyond 5 or 8 years postoperatively. Caution must be exercised when considering the indications for RSA, particularly in younger patients.

Combining small-head HHR with rotator cuff reconstruction offers several advantages to consider for future revision surgery. In cases where the reconstructed rotator cuff functions well, it allows for the option of performing TSA instead of RSA when revision of HHR becomes necessary due to glenoid wear. On the other hand, in cases where the reconstructed rotator cuff becomes insufficient and requires revision, performing RSA is easier compared to revising RSA from RSA, as the glenoid remains untouched in the case of HHR. Additionally, the postoperative shoulder function of revision RSA from HHR can also be improved compared to the unfavorable outcomes observed after revising RSA from RSA.[26] Therefore, our procedure is recommended, especially for younger patients with CTA who may require revision in the future. The results of the current study indicated our procedure offered a reliable long-term option for patients with CTA, including both elderly and younger patients. This surgical strategy can be considered a viable alternative for young patients and individuals with high-risk medical comorbidities for whom RSA may be unsuitable.

While, patients undergoing CTA often have a history of previous surgeries, such as rotator cuff repair or acromioplasty. It is important to note that the coracoacromial ligament serves as an anterosuperior restraint following HHR in shoulders with rotator cuff deficiency.[13] Field et al examined the outcomes of HHR in CTA patients with a mean follow-up of 33 months (range, 24-55 months), revealing that patients who had previously undergone rotator cuff repair with formal acromioplasty prior to the HHR experienced unfavorable outcomes.[6] Furthermore, some of these patients exhibited anterosuperior escape of the humeral head due to disruption of the coracoacromial arch. In cases of CTA, it is not uncommon to encounter anterosuperior instability resulting from previous acromioplasty or subscapularis tear, leading to disruption of the coracoacromial arch. In such situations, RSA should be considered as a treatment option.

Our study had several limitations. First, it was a retrospective study of a small cohort.

Second, the follow-up rate was low, primarily due to the advanced age of many patients, resulting in death or an inability to attend follow-up examinations. This could have introduced biases and affected the accuracy of long-term outcomes. Third, the evaluation of radiological changes was limited to plain radiographs. The inclusion of computed tomography (CT) scans would provide a more comprehensive assessment, allowing evaluation of radiological changes. This is particularly relevant, as the positioning of the prosthesis can contribute to radiological changes such as glenoid wear, by generating eccentric loading.[11] In future studies, a larger number of cases will be evaluated to assess the reconstructed rotator cuff, positioning of the prosthesis, and radiological changes, as well as to clarify the relationships between these factors and clinical outcomes.

Conclusion

The strategy of HHR using smaller head combined with rotator cuff reconstruction for CTA yielded long-term pain relief and functional improvement without any complications or loosening of the prosthesis. Our study data indicate that this procedure can be considered as a viable alternative for the patients with CTA for whom RSA may not be suitable, particularly younger patients.

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