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Clinical effectiveness and safety of the extended humeral head arthroplasty for selected patients with rotator cuff tear arthropathy

Frederick A. Matsen III, MD[a,*], Jeremy S. Somerson, MD[b], Jason E. Hsu, MD[a], Steven B. Lippitt, MD[c], Stacy M. Russ, BA[a], Moni B. Neradilek, MS[d]

[a]*Department of Orthopaedics and Sports Medicine, University of Washington, Seattle, WA, USA*
[b]*Department of Orthopaedic Surgery and Rehabilitation, The University of Texas Medical Branch, Galveston, TX, USA*
[c]*Department of Orthopedic Surgery, Akron Medical Center, Akron, OH, USA*
[d]*The Mountain-Whisper-Light Statistics, Seattle, WA, USA*

Background: Cuff tear arthropathy is commonly managed with a reverse total shoulder arthroplasty (RTSA). A humeral hemiarthroplasty with an extended humeral head may provide a less invasive alternative for selected patients with cuff tear arthropathy if the shoulder has preserved active elevation. Because evidence regarding this procedure is limited, we investigated its safety and efficacy in treating selected patients with cuff tear arthropathy.
Methods: We analyzed the preoperative characteristics, surgical findings, and clinical outcomes for patients selected for extended head hemiarthroplasty.
Results: For 42 patients with 2-year follow-up, there were no complications or revisions. The Simple Shoulder Test score improved from a median of 3.0 to 8.0 ($P < .001$). The median percentage of maximal possible improvement was 50% ($P < .001$). The percentage of patients able to perform each of the functions of the Simple Shoulder Test was significantly improved; for example, the ability to sleep comfortably increased from 19% to 71%, and the ability to place a coin on the shelf at shoulder level increased from 38% to 86% ($P < .001$).
Conclusions: There are circumstances in which RTSA is clearly the preferred procedure for cuff tear arthropathy, including pseudoparalysis, anterosuperior escape, and glenohumeral instability; however, in shoulders with preserved active motion and stability of the humeral head provided by an intact coracoacromial arch, the extended head humeral arthroplasty can enable selected patients to realize improved comfort and function without the potential risks of RTSA. Extended humeral head hemiarthroplasty can provide a safe and effective alternative for the management of selected patients with rotator cuff tear arthropathy and preserved active motion.
Level of evidence: Level IV series

Keywords: rotator cuff tear arthropathy; hemiarthroplasty; extended humeral head; clinical outcomes; patient selection; CTA prosthesis

The University of Washington Institutional Review Board approved this study (IRB Study #38897).

*Reprint requests: Frederick A. Matsen III, MD, Shoulder and Elbow Surgery, Department of Orthopaedics and Sports Medicine, University of Washington Medical Center, 1959 NE Pacific St, Box 356500, Seattle, WA 98195-6500, USA.

E-mail address: matsen@uw.edu (F.A. Matsen III).

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Figure 1 Femoralization and actetabularization. Anteroposterior radiograph of the right shoulder of a patient with rotator cuff tear arthropathy. Note the rounding of the proximal humerus ("femoralization") and the socket provided by the sculpted acromion ("actetabularization").[5,45,46] This type of pathoanatomy can provide stability for an extended head humeral hemiarthroplasty.

The term "rotator cuff tear arthropathy" refers to the combination of irreparable rotator cuff deficiency and glenohumeral arthritis, often characterized by superior migration of the humeral head with loss of normal tensioning of the deltoid. Rounding of the humeral tuberosity can result in a stabilizing ball-in-socket configuration described as "femoralization" of the proximal humerus and "acetabularization" of the coracoacromial arch (Fig. 1).[5,46] However, if the superior stability of the shoulder has been compromised, for example, by a prior acromioplasty, there is a risk of anterosuperior escape with loss of the ability to actively elevate the arm (Fig. 2).[73]

In 1983, Neer et al[52] recommended treatment of rotator cuff tear arthropathy using a "total shoulder replacement with rotator-cuff reconstruction and special rehabilitation." However by 1988, it was recognized that in the presence of rotator cuff deficiency, an anatomic total shoulder arthroplasty carries an increased risk of "rocking horse" loosening of the glenoid component.[10,30] By 1991, this recognition led to the concept of avoiding a glenoid component by placing an appropriately sized humeral hemiarthroplasty in the socket provided by the "acetabularized" coracoacromial arch in cuff tear arthropathy shoulders with preserved active elevation.[4,5]

The reverse total shoulder arthroplasty (RTSA) is now frequently used in the management of rotator cuff-deficient shoulders, especially in those with pseudoparalysis or anterosuperior instability. This procedure is usually successful, but complication rates of 15% to 59% are reported for primary RTSA.[1,8,9,12,13,15,22-25,29,32,34,36,42,44,50,51,53,58,61,63,64,66,71,72] Dislocation is the most common complication of RTSA, accounting for up to 30% of all complications—especially in young men with cuff tear arthropathy.[7,12,23]

Surgical revision of an unstable RTSA has a high failure rate, again especially in younger patients.[1] The RTSA has other unique failure modes not seen with hemiarthroplasty, including neurologic complications from over-lengthening of the arm, acromial and scapular spine fracture, scapular notching, baseplate loosening, dissociation of the glenosphere from the baseplate, modular humeral component dissociation, dislocation of the humeral cup from the glenosphere, and displacement, fracture, or wear of the polyethylene liner of the humeral cup.[1,6,8,9,11-15,20,22-25,29,32,34,36,39,41,42,44,50,51,53,55,58,61,63,64,66,71,72,76] The cost-effectiveness of the RTSA has been shown to largely depend on the rate of these complications.[17,57]

An extended head humeral hemiarthroplasty component was introduced in 2004 as a means for maximizing the contact area between the component articular surface and the coracoacromial arch in selected patients with rotator

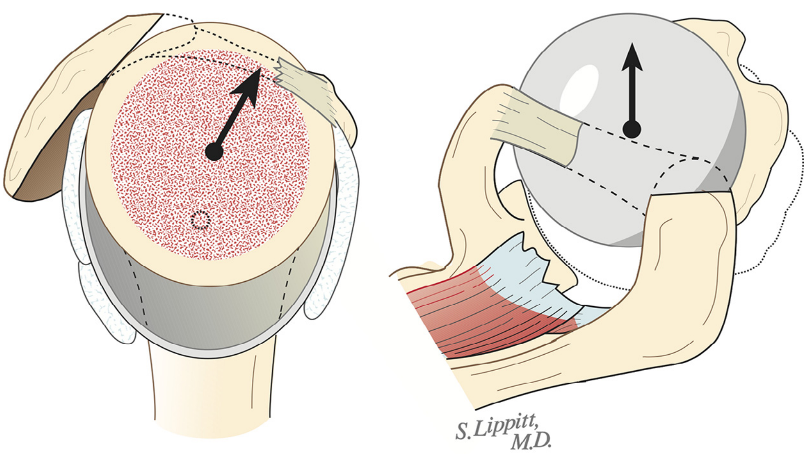

Figure 2 Anterosuperior escape. In the presence of rotator cuff deficiency, an anterior acromioplasty and section of the coracoacromial ligament may allow the humeral head to escape anterosuperiorly. (Modified by author Steven B. Lippitt from his original Fig. 16-109, p 873 in The Shoulder Rockwood and Matsen, 5th edition. Used with permission from Elsevier.[45])

tear arthropathy.[70] In this initial series, the American Shoulder and Elbow Surgeons score and visual analog scale pain scores were improved, with no dislocations at an average of 32 months of follow-up. These results prompted us to investigate further the safety and efficacy of humeral hemiarthroplasty with an extended humeral head in the management of patients with rotator cuff tear arthropathy selected using 3 criteria: preserved active elevation greater than 90°, stability of the humeral head beneath the coracoacromial arch (ie, absence of anterosuperior escape), and the patient's desire to avoid the risk of complications potentially associated with RTSA. This report analyzes the preoperative patient, clinical, and radiographic characteristics, surgical findings and technique, and the clinical outcomes for 50 prospectively enrolled patients with rotator cuff arthropathy selected to receive a humeral component with an extended articular surface.

Materials and methods

Patient selection and inclusion criteria

In our practice, all patients undergoing elective shoulder arthroplasty are invited to enroll prospectively in a longitudinally maintained database that documents the preoperative clinical and radiographic characteristics, surgical details, and clinical outcomes. Surgical candidates with symptomatic rotator cuff tear arthropathy and retained active elevation greater than 90° are offered a discussion of the relative pros and cons of an RTSA and a hemiarthroplasty with an extended head prosthesis using standardized published handouts.[48,49] Hemiarthroplasty is not offered to patients with anterosuperior escape, pseudoparalysis, suspicion of infection, neuropathic arthropathy, or acromial fracture.

Criteria for inclusion in this analysis were (1) consent for prospective database enrollment and (2) an extended head humeral hemiarthroplasty placed for rotator cuff tear arthropathy between September 7, 2010, and February 9, 2016. Fifty patients met these criteria and accounted for 55% (50 of 91) of the patients prospectively enrolled in our database during this time interval that underwent a primary shoulder arthroplasty for rotator cuff tear arthropathy. During this period, 5 other patients with cuff tear arthropathy underwent hemiarthroplasty with a standard humeral head rather than the extended head component to allow for the preservation of a partial supraspinatus tendon attachment identified at surgery, and 36 patients with rotator cuff tear arthropathy underwent RTSA because they did not meet the criteria for a humeral hemiarthroplasty. These 41 patients were not considered in the analysis because their preoperative characteristics and surgical findings were not comparable to those of the 50 patients who underwent extended humeral head arthroplasty.

Surgical technique

The surgical technique used in the 50 patients included:

1. implantation of an extended articular surface humeral prosthesis (CTA System; DePuy, Warsaw, IN, USA; Figs. 3 and 4);

Figure 3 Preoperative pathoanatomy. Anteroposterior radiograph of a left shoulder with cuff tear arthropathy in a 65-year-old woman with a failed cuff repair and irreparable defects in the supraspinatus and infraspinatus. Note the upward displacement of the humeral head and the irregular contacting surfaces of the greater tuberosity and the acromion. On examination before surgery, she had active elevation to 110°.

2. preservation of all anterior stabilizing tissues, including the coracoacromial ligament and the sheet of clavipectoral fascia extending inferiorly from it (Fig. 5);
3. identification and mobilization of the subscapularis tendon;
4. biceps tenotomy if the long head tendon was present;
5. matching the prosthetic diameter of curvature to that of the resected humeral head (Fig. 6);
6. selecting a prosthesis height and position that retensioned the deltoid (Fig. 7);
7. fixation of the humeral stem with impaction grafting[43] to optimize bone stock and to facilitate stem removal should future surgical revision become necessary;
8. resection of any prominent tuberosity bone that might abut on the undersurface of the acromion when the arm is abducted or rotated (Fig. 8); and

Figure 4 Extended head humeral hemiarthroplasty. A postoperative radiograph at 9 years for the shoulder in Fig. 3, shows centering of the prosthesis in the glenoid and in the coracoacromial arch, which has remodeled to conform to the prosthesis.

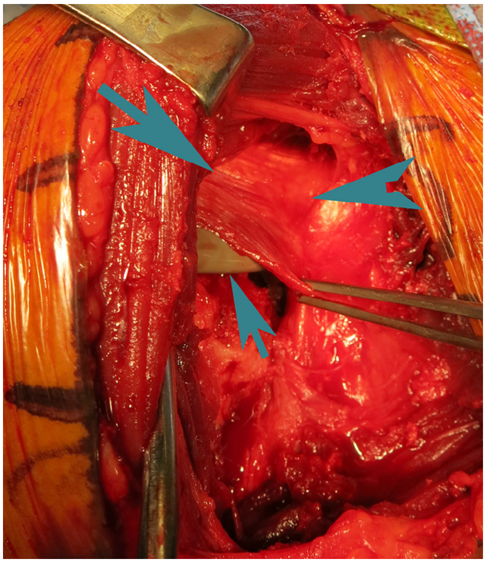

Figure 5 Maximizing anterosuperior stability. Stability is optimized by preserving not only the coracoacromial ligament (*large arrows*), but also the sheet of clavipectoral fascia that extends inferiorly from it (in forceps) shown here covering the grey humeral head trial component (*small arrow*).

9. secure reattachment of the mobilized subscapularis tendon to the lesser tuberosity using 6 transosseous nonabsorbable #2 sutures.

After surgery, patients were immediately started on active assisted range of motion exercises to 150° of flexion. External rotation was limited to 0° to protect the subscapularis repair. High-repetition, low-resistance deltoid press-up strengthening exercises were started at 6 weeks with progression from supine to sitting and standing positions.

At the time patients consented to participate and at surgery, we collected data on age, sex, diagnosis, insurance, American Society of Anesthesiologists (ASA) Physical Status Classification, 36-Item Short Form Health Survey, body mass index, prior surgery, preoperative Simple Shoulder Test (SST), presurgical optimism (rated on a 0 to 10 scale, where a "10" is very optimistic about the outcome), radiographic findings, surgical findings, and surgical variables such as humeral head diameter of curvature and thickness. Patient-reported clinical outcomes at 2 years after surgery, including the SST and the occurrence of any complications or revision procedures, were obtained by mailed questionnaire or at the time of follow-up clinic visits. The SST was selected as the outcome measure because of its documentation of the patient's ability to perform each of 12 individual shoulder functions, its widespread use in clinical research, and its demonstrated validity in evaluating the outcomes of shoulder arthroplasty.[2,16,18,19,38,47,62,65,67]

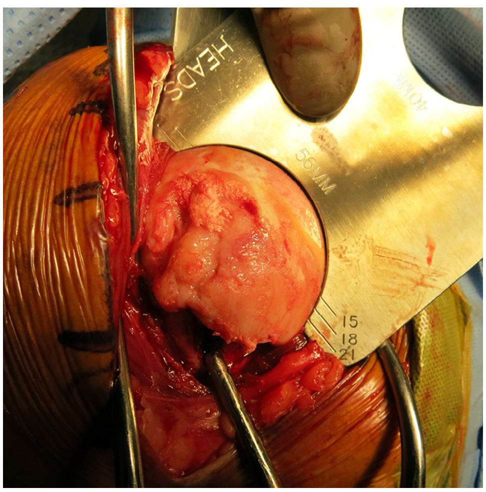

Figure 6 Matching the curvature of the resected humeral head. A sizing template is used to measure the diameter of curvature of the humeral articular surface so that it can be matched by the prosthetic humeral head.

Data analysis and statistics

The results were characterized as complications, revisions, and 2-year patient-reported clinical outcomes expressed as (1) the improvement in the percentage of patients able to perform each of the 12 individual functions of the SST (McNemar test), (2) the improvement in the total SST score (Wilcoxon signed rank test), and (3) the improvement expressed as the percentage of maximal possible improvement as 100% times the difference between the postoperative and preoperative SST scores divided by the difference between 12 (the maximal SST score) and the preoperative SST score[33,47] (Wilcoxon signed rank test).

The preoperative and surgical characteristics of the patients with 2-year follow-up were compared with those of patients lacking 2-year follow-up by using the Fisher exact test for categorical characteristics and the Wilcoxon rank sum test for continuous and ordinal characteristics. The strength of the associations of preoperative and intraoperative characteristics with the 2-year SST score and with the percentage of maximal possible improvement was quantified by Spearman correlation (ρ) for continuous and ordinal characteristics and by comparison of per-category medians (Kruskal-Wallis test) for categorical characteristics.

Results

The 50 prospectively enrolled patients were a mean ± standard deviation age of 71 ± 10 years (range, 44-90 years), and 26 (52%) were men. These patients were substantially disabled, as reflected by their preoperative SST score of 2.7 ± 2.4 of 12 (range, 0.0-8.0). Less than one-third of these patients could sleep comfortably (10 of 50), tuck in their shirt behind them (16 of 50), place a coin on a shelf at shoulder level (16 of 50), wash the back of the opposite shoulder (7 of 50), or do their regular work (7 of 50).

The ASA class was II in 29 (58%) and III in 20 (40%), and 26 (52%) had undergone prior surgery on the shoulder. Preoperative imaging showed most shoulders had Walch type A (41 of 50 [82%]) and Seebauer type 1A (28 of 50 [56%]) or 1B (15 of 50 [30%]) glenoid types.

At surgery, the supraspinatus was deficient in all 50 patients, the infraspinatus was deficient in 42 (84%), the biceps was deficient in 41 (82%), and the subscapularis was deficient in 8 (16%). The most commonly used extended head

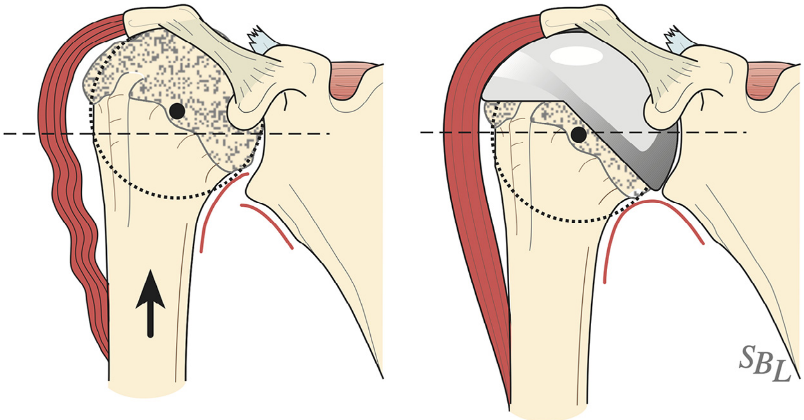

Figure 7 Deltoid tensioning. The tension in the deltoid lost as a result of the superior migration of the head (left) can be restored by surgical attention to the location of the head cut and the height of the selected prosthesis (right). The surgeon can judge the tensioning of the deltoid by pressing the elbow to the patient's side and observing it spring away when the pressure is released. (Modified by author Steven B. Lippitt from his original Fig. 16-108, p. 872 in The Shoulder Rockwood and Matsen, 5th edition. Used with permission from Elsevier.[45])

humeral head components had a diameter of curvature of 52 mm (18 of 50 [36.0%]) or 56 mm (20 of 50 [40.0%]) and a head thickness of 18 mm (30 of 50 [60%]) or 23 mm (20 of 50 [40%]). The subscapularis was repaired in 46 of 50 (92%).

Of the 50 patients prospectively enrolled in the study before their extended head arthroplasty, 1 died, 1 withdrew from the study, and 6 did not return their 2-year follow-up questionnaires. The 8 missing patients had lower preoperative SST scores (0.8 ± 0.9; range, 0.0-2.0) compared with the remaining 42 that could be included in the analysis (3.1 ± 2.4; range, 0.0-8.0; $P = .007$). Of the 8 missing patients, 3 (37.5%) were covered by Medicaid in contrast to 2 of 42 (4.8%) of the included patients ($P = .024$). Otherwise, there were no statistically significant differences between the missing and included groups in age, sex, diagnosis, surgery year, narcotic use, smoking, body mass index, workers' compensation insurance, prior surgery, ASA class, presurgical optimism, radiographic findings, or surgical findings (Table I).

For the 42 patients (84%) with 2-year follow-up, there were no surgical complications and no revisions during the follow-up period. The percentage of patients able to perform each of the individual functions of the SST was significantly improved (Table II); for example, the percentage of patients able to sleep comfortably increased from 19% (8 of 42) to 71% (30 of 42), the percentage of patients able to place a coin on the shelf at shoulder level increased from 38% (16 of 42) to 86% (36 of 42), and the percentage of patients able to wash the back of the opposite shoulder increased from 17% (7 of 42) to 62% (26 of 42; $P < .001$ for each). The total SST score improved from a median of 3.0 (interquartile range [IQR], 1.0-4.8) to 8.0 (IQR, 5.0-10.0) ($P < .001$). The median

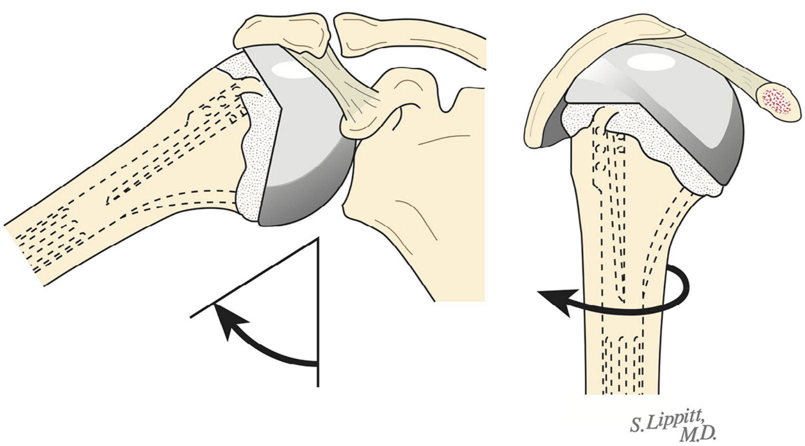

Figure 8 Tuberosity clearance. Any tuberosity bone extending beyond the curvature of the extended head is resected to avoid unwanted contact in abduction (left) or rotation (right). (Modified by author Steven B. Lippitt from his original Fig. 16-448, p. 994 in The Shoulder Rockwood and Matsen, 5th edition. Used with permission from Elsevier.[45])

Table I Comparison of preoperative characteristics between patients with and without 2-year follow-up

Variable	With 2-year follow-up		Without 2-year follow-up		*P** value
	No.	Mean ± SD (range) or No. (%)	No.	Mean ± SD (range) or No. (%)	
Age	42	71.3 ± 9.3 (43.5-90.3)	8	73.3 ± 12.5 (51.4-85.6)	.328
Sex	42		8		.456
Female		19 (45.2)		5 (62.5)	
Men		23 (54.8)		3 (37.5)	
Surgery year[†]	42		8		.498
Simple Shoulder Test score	42	3.1 ± 2.4 (0.0-8.0)	8	0.8 ± 0.9 (0.0-2.0)	**.007**
Comfortable at rest	42	27 (64.3)	8	2 (25.0)	.056
Sleep comfortably	42	8 (19.0)	8	2 (25.0)	.653
Tuck in shirt behind	42	16 (38.1)	8	0 (0.0)	**.043**
Hand behind head	42	12 (28.6)	8	0 (0.0)	.173
Place coin on shelf	42	16 (38.1)	8	0 (0.0)	**.043**
Lift 1 lb to shoulder level	42	11 (26.2)	8	1 (12.5)	.661
Lift 8 lbs to shoulder level	42	0 (0.0)	8	0 (0.0)	—
Carry 20 lbs at side	42	18 (42.9)	8	1 (12.5)	.134
Toss underhand 10 yards	42	8 (19.0)	8	0 (0.0)	.324
Throw overhand 20 yards	42	0 (0.0)	8	0 (0.0)	—
Wash opposite shoulder	42	7 (16.7)	8	0 (0.0)	.580
Do regular work	42	7 (16.7)	8	0 (0.0)	.580
Optimism	41	8.8 ± 1.2 (5.0-10.0)	8	8.2 ± 1.5 (6.0-10.0)	.319
Prior surgery	42	22 (52.4)	8	4 (50.0)	>.999
ASA class	42		8		.289
II		23 (54.8)		6 (75.0)	
III		18 (42.9)		2 (25.0)	
IV		1 (2.4)		0 (0.0)	
Body mass index, kg/m^2	42	30.5 ± 6.2 (19.9-45.9)	8	30.6 ± 5.1 (22.5-38.1)	.825
Race	42		8		.414
Black or African American		1 (2.4)		1 (12.5)	
Asian		1 (2.4)		0 (0.0)	
White		40 (95.2)		7 (87.5)	
Insurance[‡]					
Medicare	42	34 (81.0)	8	4 (50.0)	.082
Medicaid	42	2 (4.8)	8	3 (37.5)	**.024**
Labor and Industries	42	3 (7.1)	8	0 (0.0)	>.999
Commercial	42	18 (42.9)	8	6 (75.0)	.132
Tobacco use	42		8		.555
Never		14 (33.3)		3 (37.5)	
Quit		19 (45.2)		2 (25.0)	
Passive		4 (9.5)		1 (12.5)	
Yes		5 (11.9)		2 (25.0)	
Narcotics pain medication	42	16 (38.1)	8	3 (37.5)	>.999
Depression	42	13 (31.0)	8	5 (62.5)	.118
Rheumatoid arthritis	42	6 (14.3)	8	2 (25.0)	.598
Radiographic findings					
Glenoid type	42		8		.469
A1		10 (23.8)		3 (37.5)	
A2		25 (59.5)		3 (37.5)	
B1		6 (14.3)		2 (25.0)	
B2		1 (2.4)		0 (0.0)	
Scapular body angle, °[§]	42	81.8 ± 10.6 (60.0-100.0)	8	75.2 ± 16.6 (44.0-90.0)	.337
Humeral centering on axillary view[‖]	42	0.6 ± 0.1 (0.3-0.9)	8	0.6 ± 0.1 (0.5-0.8)	.643
Acromiohumeral interval, mm	42	2.1 ± 2.3 (0.0-13.0)	8	1.6 ± 1.6 (0.0-4.0)	.694

(*Continued on next page*)

Table I (*Continued*)

Variable	With 2-year follow-up		Without 2-year follow-up		*P** value
	No.	Mean ± SD (range) or No. (%)	No.	Mean ± SD (range) or No. (%)	
Seebauer classification	42		8		.312
1A		22 (52.4)		6 (75.0)	
1B		14 (33.3)		1 (12.5)	
2A		4 (9.5)		0 (0.0)	
2B		2 (4.8)		1 (12.5)	
Acetabularization	42	17 (40.5)	8	2 (25.0)	.693
Femoralization	42	24 (57.1)	8	3 (37.5)	.444
Surgical findings and procedure	42		8		.761
Subscapularis condition					
Normal		21 (50.0)		4 (50.0)	
Thin		15 (35.7)		2 (25.0)	
Torn		2 (4.8)		0 (0.0)	
Deficient		4 (9.5)		2 (25.0)	
Infraspinatus condition	42		8		.767
Normal		5 (11.9)		0 (0.0)	
Thin		2 (4.8)		1 (12.5)	
Torn		0 (0.0)		1 (12.5)	
Deficient		35 (83.3)		6 (75.0)	
Biceps condition	42		8		.603
Normal		1 (2.4)		1 (12.5)	
Thin		7 (16.7)		0 (0.0)	
Torn		3 (7.1)		2 (25.0)	
Deficient		31 (73.8)		5 (62.5)	
Head diameter	42		8		.242
44		1 (2.4)		1 (12.5)	
48		8 (19.0)		2 (25.0)	
52		15 (35.7)		3 (37.5)	
56		18 (42.9)		2 (25.0)	
Head height	42		8		.450
18		24 (57.1)		6 (75.0)	
23		18 (42.9)		2 (25.0)	
Subscapularis repair	42		8		.115
No repair		2 (4.8)		2 (25.0)	
Normal repair		40 (95.2)		6 (75.0)	
Biceps tenotomy	35		7		.067
No biceps surgery		34 (97.1)		5 (71.4)	
Tenotomy		1 (2.9)		2 (28.6)	

SD, standard deviation; *ASA*, American Society of Anesthesiologists.
* Fisher exact test for categorical characteristics and Wilcoxon rank sum test for continuous and ordinal characteristics. Values in bold are statistically significant ($P < .05$).
† Surgery year indicates the year the surgery was performed.
‡ Note that some patients had more than one type of insurance.
§ Angle between glenoid face and scapular body measured on the axillary view. Glenoid retroversion is 90° minus the scapular body angle.
‖ Distance measured on the axillary view from the anterior lip of the glenoid to the point of contact of the humeral head on the glenoid divided by the distance between the anterior and posterior lips of the glenoid.[69]

percentage of maximal possible improvement was 50% (IQR, 29%-79%; $P < .001$; Supplemental Video S1 and Supplemental Figs. S1 and S2).

In this selected series of patients, a variety of patient and shoulder characteristics were managed with the extended humeral head arthroplasty. The presence and extent of most of these characteristics had little significant effect on the outcome of the procedure (Table III). There were 2 exceptions. Patients acknowledging depression before surgery had lower final SST scores (median, 5) than those without depression (median, 9; $P = .037$) and lower percentage of maximal possible improvement (median, 30) compared with those not acknowledging depression (median, 64; $P = .040$). Also, the preoperative SST score was negatively correlated

Table II Clinical outcome for Simple Shoulder Test for 42 patients with 2 years of follow-up

Simple Shoulder Test	Preoperative No. (%)	2 yr postoperative No. (%)	*P* value*	Difference: preoperative to 2 yr (%)
Comfortable at rest	27 (64)	38 (90)	.015	26
Sleep comfortably	8 (19)	30 (71)	<.001	52
Tuck in shirt behind	16 (38)	27 (64)	.037	26
Hand behind head	12 (29)	34 (81)	<.001	52
Place coin on shelf	16 (38)	36 (86)	<.001	48
Lift 1 lb to shoulder level	11 (26)	30 (71)	<.001	45
Lift 8 lbs to shoulder level	0 (0)	13 (31)	ND†	31
Carry 20 lbs at side	18 (43)	28 (67)	.024	24
Toss underhand 10 yards	8 (19)	24 (57)	<.001	38
Throw overhand 20 yards	0 (0)	9 (21)	ND†	21
Wash back of opposite shoulder	7 (17)	26 (62)	<.001	45
Do regular work	7 (17)	22 (52)	<.001	35

* McNemar test.
† *P* value not defined (*ND*) due to 0% preoperative.

with the percentage of maximal possible improvement (ρ = –0.34, $P = .026$). Patients with prior surgery on the shoulder had lower median 2-year SST scores at follow-up than those without prior surgery (6 vs. 9) and lower percentages of maximal possible improvement (39 vs. 67), but with the numbers of patients in this study, these results were not statistically significant ($P = .091$ and $P = .173$, respectively). Other factors, including female sex, Medicaid or workers' compensation insurance, and the lack of actetabularization and femoralization had negative effects on the clinical outcome that were not statistically significant with the numbers of patients available.

Discussion

This study is unique because it provides a detailed analysis of the preoperative and intraoperative characteristics and the 2-year clinical outcomes for a series of patients with cuff tear arthropathy and retained active elevation selected to receive an extended head humeral hemiarthroplasty. It demonstrates that at 2 years after surgery, the patients selected for this procedure had substantial and statistically significant improvement in each of the functions of the SST without complications or revision surgery.

These outcomes should be viewed in light of certain limitations. First, the patients with rotator cuff tear arthropathy selected for this procedure had retained active elevation above 90°, despite having rotator cuff deficiency; they were typically 70 years old, with commercial or Medicare insurance, a mean preoperative SST score of 3, presurgical optimism of 9 of 10, and typically Walch type A and Seebauer type 1 glenoids without glenoid retroversion. These and other characteristics may differ from those of patients selected for surgery to treat rotator cuff tear arthropathy in other practices.

Second, longer-term follow-up of patients with the extended head hemiarthroplasty may yield different outcomes.

Third, the study focused on patient-reported clinical outcomes, it did not include provider-derived data such as range of motion or strength measurements or radiographic interpretation.

Fourth, we recognize that patients with cuff tear arthropathy and retained active elevation are likely to have a better outcome with any type of shoulder arthroplasty compared with those with pseudoparalysis and anterosuperior escape. The extended head hemiarthroplasty is contraindicated in patients with pseudoparalysis or anterosuperior instability, which resulted in a selection bias against patients who were not appropriate candidates for the procedure.

The purpose of this report was not to compare the outcomes of the extended head hemiarthroplasty with those with RTSA; rather, the purpose was to show the safety and efficacy of the extended head hemiarthroplasty in carefully selected patients. Our selection criteria for extended head hemiarthroplasty differed substantially from our selection criteria for a RTSA, so we could not compare the safety and clinical outcomes for these two procedures in similar patients.

Prior publications presented the results of treatment of rotator cuff arthropathy with a standard head hemiarthroplasty[4,5,21,26,31,35,37,40,42,54,56,59,60,69,74,75,77] or a mixed series of standard head hemiarthroplasties and extended head arthroplasties.[68,76] However, since the initial 2004 report of the use of the extended head hemiarthroplasty for cuff tear arthropathy,[70] we were able to locate only 3 publications reporting the outcomes for smaller numbers of patients with cuff tear arthropathy treated exclusively by humeral hemiarthroplasty with an extended humeral head prosthesis.

Arnold et al[3] presented 24 patients with an average postoperative SST score of 9, but the preoperative SST scores were not provided. Only 1 complication occurred, an infection that

Table III Association between preoperative and intraoperative risk factors with 2-year Simple Shoulder Test and 2-year percentage maximal possible improvement

Variable	Association with 2-yr SST score			Association with 2-year %MPI		
	No.	ρ* or median (IQR)†	*P* value	No.	ρ* or median (IQR)†	*P* value
Age	42	0.19	.239	42	0.14	.382
Sex			.090			.383
Female	19	7.0 (4.5-9.5)		19	40.0 (23.6-73.9)	
Men	23	9.0 (6.5-10.5)		23	50.0 (36.9-82.9)	
Surgery year	42	0.15	.341	42	0.08	.602
Simple Shoulder Test score	42	0.02	.903	42	−0.34	.026
Optimism	41	0.16	.313	41	0.13	.412
Prior surgery			.091			.173
No	20	9.0 (7.0-10.0)		20	66.7 (35.3-80.5)	
Yes	22	6.0 (4.2-9.8)		22	38.8 (15.0-65.6)	
ASA class			.339			.629
II	23	8.0 (5.0-10.0)		23	50.0 (29.3-69.7)	
III	18	8.5 (6.0-10.0)		18	63.1 (31.9-81.4)	
IV	1	3.0 (3.0-3.0)		1	25.0 (25.0-25.0)	
Body mass index	42	0.15	.336	42	0.26	.094
Race			.458			.601
Black or African American	1	10.0 (10.0-10.0)		1	66.7 (66.7-66.7)	
Asian	1	10.0 (10.0-10.0)		1	80.0 (80.0-80.0)	
White	40	8.0 (5.0-10.0)		40	50.0 (27.7-76.7)	
Insurance						
Medicare			.202			.144
No	8	6.0 (4.8-8.5)		8	39.6 (14.2-50.0)	
Yes	34	9.0 (5.2-10.0)		34	63.1 (28.9-81.8)	
Medicaid			.211			.287
No	40	8.5 (5.0-10.0)		40	50.0 (27.7-80.5)	
Yes	2	5.0 (5.0-5.0)		2	30.0 (30.0-30.0)	
Labor and Industries			.290			.083
No	39	8.0 (5.0-10.0)		39	50.0 (30.0-80.9)	
Yes	3	4.0 (3.5-7.0)		3	−12.5 (−22.9 to 18.8)	
Commercial			.131			.401
No	24	9.5 (5.0-10.0)		24	56.2 (29.6-82.2)	
Yes	18	7.5 (5.0-9.0)		18	45.8 (24.1-66.7)	
Tobacco use			.563			.619
Never	14	9.5 (7.2-10.0)		14	69.7 (35.0-81.4)	
Quit	19	7.0 (5.0-9.0)		19	40.0 (26.8-66.7)	
Passive	4	7.5 (4.8-10.5)		4	41.7 (32.5-62.5)	
Yes	5	8.0 (6.0-10.0)		5	50.0 (−20.0 to 50.0)	
Narcotics pain medication			.638			.429
No	26	9.0 (5.0-10.0)		26	56.8 (31.6-78.2)	
Yes	16	7.0 (4.8-10.0)		16	37.5 (26.4-77.1)	
Depression			.037			.040
No	29	9.0 (6.0-10.0)		29	63.6 (37.5-81.8)	
Yes	13	5.0 (4.0-9.0)		13	30.0 (20.0-62.5)	
Rheumatoid arthritis			.587			.640
No	36	8.0 (5.0-10.0)		36	50.0 (29.6-73.3)	
Yes	6	9.0 (6.5-10.0)		6	60.0 (28.8-81.4)	
Radiographic findings						
Glenoid type			.594			.422
A1	10	5.0 (4.2-9.8)		10	39.0 (−3.8 to 71.2)	
A2	25	9.0 (7.0-10.0)		25	63.6 (33.3-81.8)	
B1	6	6.5 (5.2-8.5)		6	40.0 (30.0-50.0)	
B2	1	9.0 (9.0-9.0)		1	66.7 (66.7-66.7)	
Scapular body angle	42	−0.17	.282	42	−0.17	.283

(*Continued on next page*)

Table III (*Continued*)

Variable	Association with 2-yr SST score			Association with 2-year %MPI		
	No.	ρ* or median (IQR)†	*P* value	No.	ρ* or median (IQR)†	*P* value
Humeral centering on axillary view	42	−0.06	.684	42	−0.22	.169
Acromiohumeral interval (mm)	42	−0.24	.130	42	−0.20	.210
Seebauer classification			.190			.432
1A	22	9.0 (5.0-10.0)		22	64.6 (29.8-79.5)	
1B	14	8.0 (6.0-10.0)		14	45.0 (30.0-82.5)	
2A	4	4.0 (3.0-5.5)		4	23.8 (4.4-38.5)	
2B	2	7.5 (7.2-7.8)		2	56.8 (53.4-60.2)	
Acetabularization			.179			.154
No	25	7.0 (5.0-10.0)		25	40.0 (25.0-66.7)	
Yes	17	9.0 (7.0-10.0)		17	62.5 (37.5-81.8)	
Femoralization			.121			.353
No	18	6.5 (4.2-9.0)		18	40.8 (25.9-66.7)	
Yes	24	9.0 (6.8-10.0)		24	50.0 (30.0-82.2)	
Surgical findings and procedure						
Subscapularis condition			.876			.808
Infraspinatus condition			.493			.439
Biceps condition			.998			.761
Head diameter			.598			.783
Head height			.673			.584
Subscapularis repair			.699			.767
Biceps tenotomy			.397			.321

SST, Simple Shoulder Test; *%MPI*, percentage maximum positive improvement; *IQR*, interquartile range; *ASA*, American Society of Anesthesiologists.
* Spearman correlation analysis (association with continuous and ordinal risk factors).
† Median comparison/Kruskal-Wallis test (association with categorical risk factors).

required surgical revision. None of the shoulders were unstable at a mean follow-up of 30 months. A second publication by the same group[28] reported an improvement in the average SST score from 4 to 9 in 15 patients with minimum 2-year outcomes after extended head hemiarthroplasty. Within the first 2 years after hemiarthroplasty, 1 patient was revised to an RTSA. Filho et al[27] presented 23 patients with significant improvement in the University of California Los Angeles Shoulder Rating Scale scores and no complications or revisions at an average follow-up of 20 months.

Although these publications did not include a detailed analysis of the preoperative and surgical characteristics of the patients treated, their results were consistent with those in this study, demonstrating that the extended head humeral hemiarthroplasty can be a safe and effective surgical procedure for selected patients with rotator cuff tear arthropathy and retained active elevation.

The principal alternative procedure for the surgical management of cuff tear arthropathy is the RTSA in which a polyethylene-lined prosthetic humeral cup articulates with a glenosphere attached to a baseplate screwed to the scapula. There are many circumstances in which the RTSA is clearly the preferred procedure, such as pseudoparalysis, anterosuperior escape, failed arthroplasty, complex fractures, coracoacromial arch deficiency, anteroposterior glenohumeral instability, and deltoid deficiency. However, in shoulders with preserved active motion and stability of the humeral head provided by an intact coracoacromial arch, the less invasive extended head humeral arthroplasty may provide selected patients with the opportunity for improved comfort and function without the risk of complications potentially associated with RTSA. Because the impaction grafted extended head hemiarthroplasty preserves humeral and glenoid bone stock, revision to an RTSA would be straightforward should the extended head hemiarthroplasty fail to provide the desired shoulder comfort and function.

Conclusion

Extended humeral head hemiarthroplasty may provide a safe, effective, and less invasive alternative to RTSA for the management of selected patients with rotator cuff tear arthropathy if they have preserved active motion and a stabilizing coracoacromial arch.

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Supplementary data

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