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Primary reverse shoulder arthroplasty: how did medialized and glenoid-based lateralized style prostheses compare at 10 years?

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Background: The purpose of this study was to compare long-term outcomes, complications, and reoperation rates of primary reverse total shoulder arthroplasty (RTSA) performed at a single institution using 2 implant designs: a Grammont medialized prosthesis (medialized [M] group) and a Frankle glenoid-based lateralized prosthesis (glenoid-lateralized [GL] group).

Methods: Between 2004 and 2008, 100 consecutive single-institution primary RTSAs were performed by reconstructive shoulder surgeons who were not design consultants, with the aim of obtaining 10-year follow-up: 56 in the M group and 44 in the GL group. Patients were followed up until death, until revision surgery, or for a minimum of 10 years.

Results: Of 100 patients, 87 had more than 2 years' follow-up (mean, 77 months). A subset analysis of 41 patients with an average of 10.2 years' follow-up showed sustained long-term outcomes. RTSA provided clinical improvements without significant differences between the M and GL groups, except for improved active forward elevation in the M group (144° in M group vs. 115° in GL group, $P = .002$). Reoperation was required in 6 shoulders (10-year cumulative incidence of 3 [5%] in M group vs. 3 [8%] in GL group) for a total of 16 complications (10-year cumulative incidence of 8 [14%] in M group vs. 8 [20%] in GL group). Notching rates were significantly higher in the M group (77% in M group vs. 47% in GL group, $P = .013$); differences in severe notching (grade 3 or 4) were clinically relevant but did not reach statistical significance (23% in M group vs. 9% in GL group, $P = .22$).

Conclusion: Primary RTSA using these first 2 prosthesis designs was associated with good outcomes and low reoperation (5%-8%) and complication (14%-20%) rates at 10 years. The M group had higher rates of notching. These results may provide a benchmark for comparison with newer implants, especially considering that these results include the early RTSA implantation learning curve.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Reverse total shoulder arthroplasty; long term; outcomes; prosthesis design; osteoarthritis

Institutional Review Board approval has been received from Mayo Clinic (no. 16-006966).

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Since its approval by the US Food and Drug Administration in November 2003, reverse shoulder arthroplasty (RTSA) use has seen increasing popularity. Previous studies have shown an overall increase in the number of total shoulder arthroplasties performed in the United States between 2002 and 2011.[9,15,22] RTSA use has played a significant role in the acceleration in the number of total shoulder arthroplasties performed, with roughly 10,000 RTSAs performed in the United States in 2007, a 5-fold increase over 2004.[12] Estimates indicate that 30,000 reverse total shoulder arthroplasties (RTSAs) were performed in 2012.[15] In addition, a recent study showed RTSAs accounting for 42% of all primary shoulder arthroplasties in 2011.[14]

Along with the aging population, RTSA has evolved to see broadened indications and alternate prosthetic designs.[14] Complication rates have been reported to range from 19% to 68%, including infection, instability, mechanical implant failure or dissociation, acromial or spine fracture, scapular notching, periprosthetic fracture, and neurologic injury.[1,3-5,10,12,20,21,23] Bacle et al[2] recently reported on their long-term outcomes with a mean follow-up period of 12.5 years. They reported an overall complication rate of 29%, with 10% occurring after 2 years. Although surgeon experience may play a role in the complication profile, even conservative reports of complication rates are concerning as the popularity of the implant grows in the United States.

The majority of long-term studies on RTSA have reported on the traditional Grammont-style prosthesis. Bacle et al[2] reported a 93% 10-year overall prosthetic survival rate free of revision. Early on, our institution adopted 2 different RTSA designs: one design combining a medialized glenoid with a 155° inlay polyethylene humeral component along the principles of Dr. Grammont and another design combining a lateralized glenoid with a 135° inlay polyethylene humeral component according to the principles proposed by Dr. Frankle.[7] Frankle's lateralized glenoid design was aimed at providing a greater impingement-free range of motion and restoring optional muscle length-tension dynamics. Initially, cemented fixation of the humeral component was recommended for both designs.

The purpose of this study was to compare the long-term outcomes, notching rates, complications, and reoperation rates of primary RTSA performed at a single institution using both implant designs: the Grammont medialized prosthesis (medialized [M] group) and the Frankle glenoid-based lateralized prosthesis (glenoid-lateralized [GL] group). We hypothesized that there would be no significant difference in long-term clinical outcomes, complications, or reoperation rates between the 2 groups, but we expected to see higher rates of notching in the Grammont prosthesis group.

Materials and methods

Our institutional joint registry database was queried to identify all primary RTSAs performed using a Delta III prosthesis (DePuy, Warsaw, IN, USA), Delta Xtend prosthesis (DePuy), or Encore/DJO prosthesis (DJO Surgical, Austin, TX, USA) between 2004 and 2008. These study years were selected to provide the potential for 10 years of follow-up. Patients were included if they received a primary RTSA at our institution during the selected study years. Patients with a revision arthroplasty were excluded from this study. A total of 100 consecutive primary RTSAs were identified. Our joint registry database captures demographic and clinical variables at the time of joint arthroplasty and at postoperative follow-up times of 1 year, 2 years, and 5 years, as well as every 5 years thereafter. Patients are invited to return for a physical examination and radiographs at each follow-up time interval. Those not returning for follow-up are assessed using a validated, patient-reported outcome survey that also assesses reoperations at outside institutions and requests that patients send us radiographs.[19] We completed a retrospective review of this prospectively recorded information to collect clinical outcomes, complications, and reoperations. In addition, all available radiographs were reviewed according to the parameters detailed later.

Patient demographic characteristics and selection criteria

This study analyzed 100 consecutive primary RTSAs performed by 1 of 4 reconstructive shoulder surgeons. There were 66 female and 34 male patients, the average age was 73.7 years (range, 55-86 years) at the time of surgery, and the mean BMI was 29.9 (range, 17-45.5) (Table I). Most RTSAs (90 of 100, 90%) were performed for cuff tear arthropathy, with a few performed for sequelae of proximal humeral fractures (7), post-traumatic arthritis (2), or avascular necrosis (1). Patients were followed up until death, revision surgery, or their most recent clinical evaluation. The average follow-up time for the whole cohort was 77 months. A subset analysis was performed excluding patients with less than 7 years of follow-up, which yielded an average follow-up period of 123 months for 41 patients.

Implant selection and operative technique

As mentioned before, all RTSA procedures were performed using 1 of 2 prosthesis designs: a Grammont-style prosthesis with a medialized center of rotation and 155° polyethylene cemented inlay humeral component (Delta III or Delta Xtend) or a Frankle-style prosthesis with a lateralized center of rotation and a cemented inlay humeral component with a 135° polyethylene angle (Encore). Implant selection was based on surgeon preference. All stems were cemented, and no augmentations or bone grafts were used on the glenoid. There were 56 shoulders in the M group and 44 shoulders in the GL group. A standard deltopectoral approach was used for all procedures, along with a standard repair of the subscapularis tendon when tissue integrity allowed. All patients were immobilized for at least 2 weeks, with longer periods of immobilization for shoulders with subscapularis repairs.

Table I Patient demographic characteristics

	Total patients, n	Survivors, n	Sex, n		Operative laterality, n		Mean BMI	Mean age at surgery, yr
			Female	Male	Right	Left		
M group	44	24	36	20	39	17	31.6	72.6
GL group	56	28	30	14	25	19	28.5	75.1
Total	100	52	66	34	64	36	29.9	73.7
P value			.68				.036	.043

BMI, body mass index; *M*, medialized; *GL*, glenoid lateralized.

Follow-up information

At most recent analysis, 48% of patients (48 of 100) were deceased with their implants in place. This finding is not unexpected given the elapsed time from surgery over a decade ago for many of these elderly patients at the time of their index procedure. In the M group, 28 of 56 patients were deceased, with an average time from surgery to death of 7 years. In the GL group, 20 of 44 patients were deceased, with an average time from surgery to death of 6.9 years.

Of the 100 patients who underwent shoulder arthroplasties in this study, 12 died before 2-year follow-up whereas only 1 survivor was lost to follow-up before 2 years. When we exclude these 13 patients who died or were lost to follow-up before 2 years, the remaining 87 shoulders had an average clinical follow-up time of 87.2 months (range, 25-161 months). For the whole group of 100 shoulders, the average radiographic follow-up time was 52.6 months (range, 0-132 months). In addition to the 13 patients who died or were lost to follow-up before 2 years, 11 patients were lost to radiographic follow-up before 2 years. When those lost to radiographic follow-up before the 2-year mark are excluded, 76 patients were included for postoperative analysis, with an average radiographic follow-up period of 67 months (range, 25-132 months).

Clinical outcome assessment

The primary outcome of this study was revision surgery for removal or replacement of a humeral stem or glenoid metaglene. Secondary outcomes included reoperation for any reason, other complications, pain, and range of motion before surgery and at most recent follow-up. Patients were asked to quantify their pain preoperatively and postoperatively with a visual analog scale pain score (0, none; 1-3, mild; 4-7, moderate; or 8-10, severe) or to simply categorize their pain by those same descriptors. Range of motion was either determined by clinical examination at last follow-up or extracted from the standardized joint registry patient-completed questionnaire.

Radiographic assessment

Two fellowship-trained reconstructive shoulder surgeons and two orthopedic surgeons in training as fellows in shoulder and elbow surgery reviewed preoperative radiographs, radiographs obtained within the first 3 months after surgery, and radiographs obtained at most recent follow-up. Standard 3-view preoperative radiographs (internal anteroposterior, external anteroposterior, and axillary lateral) were reviewed to determine the following radiographic parameters: glenoid bone loss (none, mild, moderate, or severe), glenoid morphology according to the Favard classification for shoulders with cuff tear arthropathy, degree of subluxation (none, mild, moderate, or severe), and direction of humeral subluxation.[6,13]

Early postoperative and most recent follow-up radiographs were reviewed for the presence and extent (complete or incomplete) of linear lucency at the glenoid-implant or humerus-implant interface. Radiographic loosening was defined as a clear change in component position or a complete radiolucent line over 2 mm in thickness. Inferior scapular notching was reviewed and graded as described by the Nerot-Sirveaux classification.[17]

Statistical analysis

Descriptive statistics are reported as mean (standard deviation) or median (interquartile range) for continuous measures and as frequencies and percentages for categorical variables. Continuous variables were compared between groups using either a *t* test or the Wilcoxon rank sum test as appropriate, and categorical variables were compared between groups using either the χ^2 or Fisher exact test. The time-to-event outcomes of reoperations and complications were assessed using competing-risks analysis, in which death was considered the competing event. Kaplan-Meier survivorship curves were detailed to determine survivorship rates for the prostheses, with the endpoints defined as revision or resection for any reason. The α level was set at .05 for statistical significance.

Results

Complications and reoperations

At most recent follow-up, only 6 shoulders among 100 primary RTSAs have required reoperation (10-year cumulative incidence of 3 [5%] in M group vs. 3 [8%] in GL group; hazard ratio, 1.30; 95% confidence interval, 0.26-6.43; $P = .75$); the reasons for reoperation were dislocation (2), polyethylene disassociation (1), glenosphere disassociation (1), infection (1), and acromial stress fracture (1). Other complications included intraoperative or postoperative periprosthetic fractures (6), acromial stress

fractures (2), brachial plexopathy (1), and a distal clavicle insufficiency fracture (1), for a total of 16 complications for both groups (10-year cumulative incidence of 8 [14%] in M group vs. 8 [20%] in GL group; hazard ratio, 1.31; 95% confidence interval, 0.49-3.50; $P = .59$) (Table II).

There were 3 reoperations in the M group. One shoulder had polyethylene disassociation requiring revision within 3 months after surgery. The other reoperations comprised open reduction and internal fixation of a symptomatic acromial fracture 1 year after surgery and revision in a single patient with recurrent instability at 4 years. No secondary procedures were required for these 3 patients after their initial reoperations.

In the GL group, reoperations were performed for recurrent dislocation in 1 patient and for glenosphere disassociation in another patient within 60 days of surgery. These 2 patients underwent no further procedures. In another patient, reoperation was performed for a deep infection requiring superficial surgical wound exploration and débridement 10 years after surgery. This patient died 3 months after débridement and never underwent a formal implant revision procedure.

The overall reoperation rate was 6% (6 of 100), and the overall complication rate was 16% (16 of 100). Kaplan-Meier cumulative-incidence curves are displayed in Figure 1.

Medialized design outcome (M group)

A total of 56 RTSAs were performed in this study using the Grammont-style prosthesis. With the exclusion of the 7 patients who died within the first 2 years after surgery, the average clinical follow-up time was 85.2 months (range, 25-161 months). Preoperatively, 90% of the patients reported moderate or severe pain; at most recent follow-up, 90% of the patients reported no or mild pain. RTSA led to improvements in mean active forward elevation (from 65° to 144°, $P < .001$) and mean active external rotation (from 23° to 48°, $P < .001$).

Preoperative radiographs revealed moderate or severe superior subluxation of the humeral head in 100% of patients with cuff tear arthropathy. The Favard classification of glenoid erosion preoperatively showed the following grades for the 48 cuff tear arthropathy shoulders: E0 in 21 (43.8%), E1 in 8 (16.7%), E2 in 13 (27.1%), and E3 in 6 (12.5%).

Examination of the most recent postoperative radiographs of patients with minimum 2-year radiographic follow-up showed incomplete lucent lines around the humerus-cement interface of 24 of 44 patients (54.5%) (1 mm in 15 shoulders and 1.5 mm in 9 shoulders) and complete lucent lines around the humerus in 10 of 44 patients (22.7%) (1 mm in 5 shoulders, 1.5 mm in 3 shoulders, and 2 mm in 2 shoulders). No shoulders had evidence of gross loosening on the humeral side. and only 1 shoulder had evidence of loosening at the glenoid component–bone interface. The overall rate of radiographic loosening was 1 of 44 (2.27%), with a single shoulder demonstrating glenoid shift. The overall notching rate was 34 of 44 (77.3%), with grade 1 in 15 shoulders, grade 2 in 9, grade 3 in 6, and grade 4 in 4. Severe notching (grade 3 or 4) was present in 22.7% of the shoulders (Table III).

Glenoid-lateralized design outcome (GL group)

A total of 44 RTSAs were performed in this study using a design with a lateralized center of rotation and a cemented inlay humeral component with a 135° polyethylene angle (Encore). Six patients did not have 2-year follow-up; 5 of 6 died before 2 years. For patients with minimum 2-year follow-up, the average clinical follow-up time was 88.8 months (range, 27-151 months) and the average radiographic follow-up time was 65.1 months (range, 26-131 months). A total of 12 patients were lost to radiographic follow-up before 2 years; 7 of these patients had died.

Before surgery, all patients complained of moderate or severe pain. At most recent follow-up, 91% of the patients complained of no or mild pain ($P < .001$). RTSA using a glenoid-lateralized design resulted in improved active forward elevation (from 51° preoperatively to 116° at most recent follow-up, $P < .001$) and active external rotation (from 17° preoperatively to 38° at most recent follow-up, $P < .001$).

Preoperative radiographs revealed moderate or severe superior subluxation of the humeral head in 100% of patients with cuff tear arthropathy. The Favard classification of glenoid erosion preoperatively showed the following grades for the 42 cuff tear arthropathy shoulders: E0 in 15 (35.7%), E1 in 8 (19.1%), E2 in 12 (28.6%), and E3 in 7 (16.7%).

For shoulders with a minimum 2-year radiographic follow-up, at the most recent follow-up, there were incomplete lucent lines around the humerus-cement interface in 18 of 32 patients (56.3%) (1 mm in 9 shoulders and 1.5 mm in 9 shoulders), and 8 of 32 patients (25%) had complete lucent lines around the humerus (1 mm in 4 shoulders, 1.5 mm in 3 shoulders, and 2 mm in 1 shoulder). No patients had evidence of gross loosening on the humeral side, whereas 1 patient demonstrated evidence of loosening at the glenoid component–bone interface. The overall rate of radiographic loosening was 1 of 32 (3.1%), with glenoid shift in 1 of 32 (3.1%). The overall notching rate was 15 of 32 (46.9%), with grade 1 in 7 shoulders, grade 2 in 5, grade 3 in 2, and grade 4 in 1. Severe notching (grade 3 or 4) was present in 9.4% of the shoulders in this group.

Design comparison subset analysis

With the numbers available, differences in complication and reoperation rates between the M and GL groups did not reach statistical significance. Differences in pain and

Table II Complication and reoperation data

	Total patients, n	Mortality rate, %	Mean age at surgery, yr	Complications		Reoperations	
				n	10-yr cumulative incidence, %	n	10-yr cumulative incidence, %
M group	56	50.0	75.1	8	14.4	3	5.4
GL group	44	45.5	72.6	8	20.1	3	8.0

M, medialized; *GL*, glenoid lateralized.

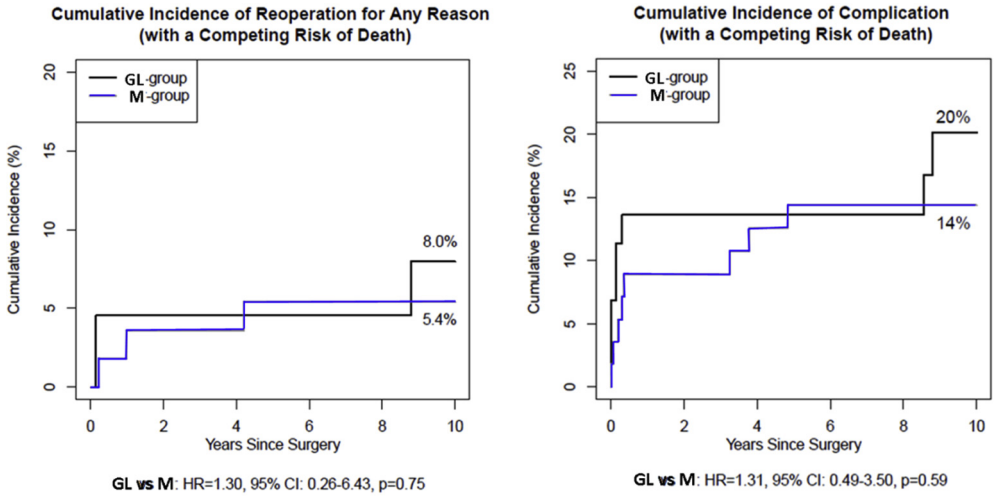

Figure 1 Survivorship analysis. *GL*, glenoid lateralized; *M*, medialized; *HR*, hazard ratio; *CI*, confidence interval.

motion were also not statistically significant except for improved active forward elevation in the M group (144° in M group vs. 115° in GL group, $P = .002$). In addition, clinical outcomes were compared in a subset of 41 patients followed up for a mean of 10.2 years; the only statistically significant difference at long-term follow-up was better active elevation in the M group (Table IV).

For shoulders with greater than 2 years of radiographic follow-up (44 in M group and 32 in GL group), overall notching rates were significantly higher in the M group (77% in M group vs. 47% in GL group, $P = .013$). Differences in severe (grade 3 or 4) notching were clinically relevant but did not reach statistical significance (23% in M group vs. 9% in GL group, $P = .22$). No significant difference in component loosening on radiographs was noted ($P = .82$).

Discussion

Since RTSA early adoption in the United States in 2004, there have been many RTSA design iterations aimed at maximizing function and longevity while limiting complications and implant failure. However, the fundamental RTSA design debate for many shoulder and elbow surgeons over the past decade has remained: medialized vs. lateralized designs. Our study provides a unique perspective as it was performed at an early-adopting center in the United States with shoulder reconstruction surgeons using both designs and no design-surgeon bias during the years of study. Despite some RTSA technique changes since early adoption, our medium- to long-term outcomes serve as a benchmark for future implant studies. With an overall reoperation rate of 6% and complication rate of 16% in patients with primary RTSA performed 10 to 14 years ago, survivorship of primary RTSA in the elderly patient with cuff tear arthropathy is encouraging.

Bacle et al[2] reported on the European long-term experience using the Grammont-style prosthesis, with a 29% complication rate and 12% revision rate. They reported a 10-year overall prosthetic survival rate free of revision of 93%. Cuff et al[8] recently reported on 42 primary RTSAs implanted using a design with glenoid lateralization. The 10-year overall survival rate free of revision was 90.7%, with maintained improvements in outcome scores and range of motion. Similarly to the findings of these 2 previous long-term studies, our study demonstrated satisfactory clinical and radiographic outcomes with low reoperation and complication rates. Despite the limited number of survivors at long-term follow-up, it is

Table III Radiographic profile at minimum 2-year follow-up

	M group (n = 44)	GL group (n = 32)	Total
Average image follow-up, mo	68.48	65.07	62.85
Preoperative glenoid erosion, %			
None	39.02	37.50	
Mild	31.71	40.63	
Moderate	26.83	15.63	
Severe	0.00	6.25	
Preoperative Favard classification, %			
E0	43.75	35.71	
E1	16.67	19.05	
E2	27.08	28.57	
E3	12.50	16.67	
E4	0.00	0.00	
Preoperative subluxation severity, %			
None	2.44	0.00	
Mild	0.00	0.00	
Moderate	21.95	21.88	
Severe	73.17	78.13	
Radiographic loosening, %	2.27	3.13	
Humeral lucency, %			
None	24.39	18.75	
1 mm incomplete	34.15	28.13	
1 mm complete	12.20	12.50	
1.5 mm incomplete	19.51	28.13	
1.5 mm complete	4.88	9.38	
2 mm	4.88	3.13	
Glenoid lucency, %			
None	80.49	84.38	
1 mm incomplete	0.00	6.25	
1 mm complete	0.00	0.00	
1.5 mm incomplete	4.88	3.13	
1.5 mm complete	7.32	0.00	
2 mm	7.32	6.25	
Humeral position shift, %	0.00	0.00	
Glenoid position shift, %	2.27	3.13	
Overall notching, %	77.27	46.88	
Notching, %			
0	22.73	53.13	
1	34.09	21.88	
2	20.45	15.63	
3	13.64	6.25	
4	9.09	3.13	

M, medialized; *GL*, glenoid lateralized.

encouraging to note relatively low rates of complications and reoperations with no major differences between the 2 groups. No statistically significant differences in complication or revision rates were found between the M group and GL group.

Although the primary endpoint of this study was implant revision, we also performed a detailed radiographic review to identify evidence of implant loosening and scapular notching. An accepted criticism of the Grammont design is the high rate of scapular notching, although the effect this portends to functional outcome is debated. At long-term follow-up, Bacle et al[2] reported a 73% rate of scapular notching; 61% of these cases were classified as Sirveaux stage 1 or 2 and the other 39%, as stage 3 or 4. The same study reported a 39% increase in the rate of scapular notching since medium-term follow-up. It is interesting to note that Bacle et al reported no statistically significant differences in long-term Constant scores between patients without notching or with a lower stage of scapular notching (0, 1, or 2) and patients with a higher stage of scapular notching (3 or 4).

Other studies have reported rates of stage 3 or 4 notching using a Grammont-style RTSA as low as 17% and as high as 62%.[16,18] In our study, in the M group, the overall notching rate was similar, at 77%, with severe notching (stage 3 or 4) present in 23% of the shoulders. The lower rate of severe notching in our cohort is likely attributable to the shorter follow-up time compared with the long-term study of Bacle et al[2]; it stands to reason that as time progresses, notching rates will increase.

One of the proposed benefits of glenoid lateralization is to minimize scapular notching rates. Cuff et al[8] reported their long-term notching rate at a modest 15%, with grade 1 notching in patients except 1 patient with grade 2 notching. The radiographic follow-up period in their study was a mean of 68 months, with notching appearing at an average of 49 months. In our study, the GL group demonstrated higher rates of notching than in the aforementioned study. The overall notching rate was 46.9%, with 37.5% being grade 1 or 2. Severe notching (grade 3 or 4) was present in 9.4% of the shoulders in our GL group. These higher notching rates compared with previous reports may be attributable to variations in surgical technique related to implant position.

Erickson et al[11] conducted a systematic review evaluating range-of-motion differences in RTSA with 135° and 155° neck-shaft angle designs. Their review included 3434 shoulders with an average follow-up period of 3 years. The results showed significant improvements in external rotation, forward elevation, and abduction with both implants but showed significantly greater improvements in external rotation with the 135° prosthesis. Although the hypothesis of Erickson et al was similar to ours in that we both expected no significant difference between the groups, the results differed. Our results showed no significant difference in external rotation but a significant improvement in forward elevation with the 155° implant. There may be several reasons for these differences. Erickson et al included many different implants in their study and only focused on the neck-shaft angle, ignoring all other implant characteristics such as the center of rotation and amount of

Table IV Clinical comparison

	GL group (n = 44)	M group (n = 56)	Total (N = 100)	*P* value
Active elevation				
Preoperatively				.18
n	44	52	96	
Mean (SD), °	51.3 (37.6)	65.1 (46.6)	58.8 (43.0)	
Median, °	40	60	50	
Q1, Q3, °	20.0, 72.0	25.0, 95.0	20.0, 82.5	
Range, °	0.0-160.0	5.0-165.0	0.0-165.0	
Postoperatively at minimum 2-yr follow-up				.006
n	36	49	85	
Mean (SD), °	122.5 (47.1)	147.3 (37.4)	136.8 (43.3)	
Median, °	140	150	150	
Q1, Q3, °	90.0, 155.0	130.0, 180.0	120.0, 170.0	
Range, °	0.0-180.0	20.0-180.0	0.0-180.0	
Postoperatively at minimum 7-yr follow-up				.005
n	19	21	40	
Mean (SD), °	118.9 (50.1)	156.9 (26.6)	138.9 (43.5)	
Median, °	130	160	150	
Q1, Q3, °	90.0, 150.0	150.0, 180.0	120.0, 175.0	
Range, °	0.0-180.0	80.0-180.0	0.0-180.0	
Active external rotation				
Preoperatively				.44
n	42	52	94	
Mean (SD), °	16.7 (19.1)	22.4 (25.2)	19.8 (22.7)	
Median, °	20	17.5	20	
Q1, Q3, °	0.0, 30.0	5.0, 40.0	0.0, 30.0	
Range, °	−30.0 to 60.0	−20.0 to 80.0	−30.0 to 80.0	
Postoperatively at minimum 2-yr follow-up				.12
n	37	48	85	
Mean (SD), °	40.4 (30.4)	51.4 (32.2)	46.6 (31.7)	
Median, °	40	55	40	
Q1, Q3, °	30.0, 60.0	30.0, 80.0	30.0, 70.0	
Range, °	−40.0 to 90.0	−30.0 to 120.0	−40.0 to 120.0	
Postoperatively at minimum 7-yr follow-up				.31
n	20	21	41	
Mean (SD), °	39.0 (34.0)	50.2 (36.4)	44.8 (35.3)	
Median, °	40	50	40	
Q1, Q3, °	30.0, 65.0	30.0, 80.0	30.0, 70.0	
Range, °	−40.0 to 90.0	−30.0 to 120.0	−40.0 to 120.0	
Pain, n (%)				
Preoperatively				.14
Missing	0	1	1	
None	0 (0.0)	3 (5.5)	3 (3.0)	
Mild	0 (0.0)	1 (1.8)	1 (1.0)	
Moderate	6 (13.6)	13 (23.6)	19 (19.2)	
Severe	38 (86.4)	38 (69.1)	76 (76.8)	
Postoperatively				.46
Missing	1	2	3	
None	20 (46.5)	32 (59.3)	52 (53.6)	
Mild	20 (46.5)	19 (35.2)	39 (40.2)	
Moderate	3 (7.0)	3 (5.6)	6 (6.2)	
ASES score at last examination				.41
n	21	37	58	
Mean (SD)	69.2 (20.0)	73.0 (15.3)	71.6 (17.1)	
Median	71.6	78.3	72.5	
Q1, Q3	55.0, 80.0	61.6, 84.9	58.3, 84.9	
Range	18.3-100.0	43.3-98.3	18.3-100.0	

GL, glenoid lateralized; *M*, medialized; *SD*, standard deviation; *Q1*, first quartile; *Q3*, third quartile; *ASES*, American Shoulder and Elbow Surgeons.

lateralization of the glenoid and humerus; this approach yields a much more heterogeneous sample. Furthermore, nearly half of the studies reported an authorship conflict of interest; this is relevant when the range of motion is physician reported and could lead to a bias in range-of-motion reporting. Conversely, a strength of our study is that there was no conflict of interest and no implant designers reporting outcomes. Both studies conclude that patients see a significant improvement in range of motion with either implant design.

Certainly, a strength of this study is the relatively high volume of primary RTSAs performed during the study period by shoulder reconstructive surgeons at a single institution. Both the medialized design and the glenoid-lateralized design were used based solely on surgeon preferences. In fact, several surgeons used both designs during the study period. It is important to note that the surgeons in this study were not design surgeons or consultants for either of the implants used during the study period, alleviating the inherent concern for selection bias in implant choice. To our knowledge, this is the only medium- to long-term follow-up study comparing RTSA outcomes and survivorship using both prosthesis designs at a single institution.

This study has limitations that one must consider. First, the retrospective nature of the study lends itself to inherent recall and observer bias. Our clinical data were gathered from self-reported joint registry questionnaires as well as clinical examinations, leading to the concern for interobserver bias; moreover, patient-reported values may not correlate to a true standardized range-of-motion measurement by a health care provider. Another limitation of this study is the high mortality rate, with nearly 50% of patients having died before 10-year follow-up. Presumably, these patients died with a functional implant in place, but this cannot be confirmed. This study is also subject to selection bias as the primary surgeon had full discretion on implant selection during the study; there was no randomization between the implant designs. Similarly, the surgical technique used in the early adoption years was not standardized and has nuanced differences from our current technique regarding implant placement and soft tissue tension. These aforementioned technical differences could prove to affect long-term clinical and radiographic outcomes in the future.

Conclusion

Primary RTSA using both an implant with a medialized glenoid and an inlay humeral component with a 155° polyethylene angle and an implant with a lateralized glenoid and a 135° polyethylene angle was associated with satisfactory clinical outcomes and a low reoperation rate in patients undergoing surgery more than 10 years ago. The 10-year cumulative incidences of reoperations and complications were 5% to 8% and 14% to 20%, respectively. Aside from better active elevation in the M group, no substantial differences were found between the 2 implant styles in terms of clinical outcomes, complications, and reoperations. The M group had higher overall rates of notching, although differences in rates of severe notching were not statistically significant between the 2 groups. Almost 50% of the patients who underwent the procedure died within 10 years with a presumed satisfactory implant in place. The results of this study can only be extrapolated to primary RTSA for cuff tear arthropathy, but they definitely provide a benchmark for comparison with newer implants, especially considering that the procedures reported here do include the early learning curve for implantation of RTSA at our institution.

Disclaimer

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