Comparison of Utilization and Clinical Outcomes for Two Different Reverse Total Shoulder Arthroplasty Glenoid Designs

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Introduction: Reverse total shoulder arthroplasty (rTSA) is increasingly used as the prosthesis of choice for patients with end-stage degenerative conditions of the shoulder. rTSA prosthesis designs are offered in various sizes and styles to accommodate varying patient anatomy, morphology, and wear/deformity patterns. However, there is little research describing how surgeons select one design over another. The purpose of this study is to analyze an international multicenter database of a single shoulder prosthesis to compare demographics, comorbidities, surgical/operative parameters, and clinical/radiographic outcomes associated with patients who received a standard-size rTSA baseplate (having a glenosphere diameter of 38, 42, and 46mm) to patients who received a small-size rTSA baseplate (having a glenosphere diameter of 36 or 40mm).

Methods: An international multicenter database of a single shoulder prosthesis was analyzed to compare rTSA utilization and clinical/radiographic outcomes for clinical sites with access to both a small-size and a standard-size rTSA design, over the same time period. Specifically, from December 2018 to August 2021, all primary rTSA patients were included in this study if they had 2-year minimum follow-up, and were treated with either a small-size rTSA or a standard-size rTSA glenoid design. Patients were excluded if they had a history of infection or revision arthroplasty. Patients were evaluated pre-operatively and post-operatively using patient reported outcome measures (PROMs) including ASES, Constant, and SAS scoring metrics; and using VAS pain and global shoulder function. Range of motion was quantified for active abduction, forward elevation, and internal/external rotation. Complication and revision rates were also determined. To better understand the considerations for utilization between small-size and standard-size rTSA glenoid designs, patient demographics, comorbidities, surgical/operative parameters were compared between cohorts. Each cohort was compared pre-operatively and at 2-year minimum follow-up using student's t-test for continuous variables and a Wilcoxon-rank-sum test for ordinal variables.

Results: The clinical outcomes of 1,402 primary rTSA patients from 20 different clinical sites were analyzed in this study. 423 (384F/38M/1 unknown) primary rTSA patients received a small size rTSA and 979 (434F/540M/5 unknown) primary rTSA patients received a standard size rTSA. As described in Table 1, several differences were observed between rTSA glenoid design cohorts for demographics and comorbidities. Specifically, small-size rTSA patients had significantly more females (91.0% vs. 44.6%, $p<0.0001$), were shorter (63.7 vs. 67.0 inches, $p<0.0001$), weighed less (171.7 vs. 190.9 lbs, $p<0.0001$) and less commonly had a diagnoses of OA (40.8% vs. 48.5%, $p=0.0080$) and CTA (29.1% vs. 34.6%, $p=0.0466$) as compared to patients with a standard-sized rTSA glenoid. As described in Table 2, several differences were observed between rTSA glenoid design cohorts for operative/surgical and implant parameters. Specifically, small-size rTSA patients had a significantly higher rate of cemented humeral stem usage (7.6% vs. 4.2%, $p=0.0090$), significantly smaller humeral stem diameter (8.9 vs. 9.7 mm, $p<0.0001$), significantly smaller Glenosphere diameter (36.9 vs. 40.0 mm, $p<0.0001$), significantly less use of expanded offset glenospheres (5.7 vs. 10.2%, $p=0.0068$), but significantly more use of baseplate screws (3.6 vs. 3.2 screws, $p=0.0047$) as compared to patients with a standard-sized rTSA glenoid.

Regarding clinical outcomes, 94.2% of small-size rTSA patients and 94.3% of standard-size rTSA patients reported being "better" or "much better" at 2 years minimum follow-up, with only 5.8% of small-size rTSA and 5.7% of standard-size rTSA patients reported being "unchanged" or "worse". As described in Table 3, prior to surgery a few differences were observed between small-size and standard-size rTSA glenoid cohorts. Pre-operatively, small-size rTSA patients had significantly less internal rotation (2.8 vs. 3.0, $p=0.0335$), significantly more external rotation (26.2 vs. 23.7, $p=0.0490$), and a significantly lower Constant score (33.9 vs. 37.1, $p=0.0169$) as compared to patients with a standard-sized rTSA glenoid. At latest 2-year minimum follow-up, small-size rTSA patients had an average follow-up of 30.5 ± 7.0 months and standard-sized rTSA patients had an average follow-up of 33.2 ± 8.7 months. At latest follow-up, the only observed difference was that small-size rTSA patients had significantly more global shoulder function as compared to standard-sized rTSA patients (8.5 vs. 8.3, $p=0.0463$). Regarding pre-to-post-operative improvement at latest follow-up, the only observed difference was that small-size rTSA patients had significantly more Constant score improvement as compared to standard-sized rTSA patients (32.1 vs. 28.1, $p=0.0318$). Regarding radiographic outcomes, small-size rTSA patients had a 17.9% scapular notching rate (47 grade 1, 10 grade 2, and 5 grade 3), which was significantly higher than the 7.0% scapular notching rate (43 grade 1, 8 grade 2, and 1 grade 3) of standard-sized rTSA patients. Finally, no difference in complication or revision rate was observed, where small-size rTSA patients had a 1.7% complication rate and a 0.5% revision rate (1 aseptic glenoid loosening) and standard-sized rTSA patients had a 1.8% complication rate and 1.2% revision rate (3 infections, 3 instability, 3 loosening, 3 poly/tray dissociations).

Discussion: The results of this study demonstrate that patients receiving both small-size and standard-size rTSA glenoid designs achieved positive outcomes and a low revision rate at 2-year minimum follow-up with a lateralized humeral rTSA prosthesis. Some statistical differences in clinical outcomes were observed between small-size and standard-size rTSA cohorts; however, those differences were small and lower than the MCID associated with each outcome measure. This study several limitations. First, our study design was a retrospective database analysis of patients from 20 different clinical sites and this usage of multiple surgeons introduces substantial variability in technique and implant selection and we do not know the specific criteria pertaining to surgeon selection a small-size versus and standard-size rTSA glenoid. Second, radiographic evaluation was performed by the implanting surgeon and we did not utilize multiple reviewers to assess inter-observer reliability. Third, while numerous parameters were identified to be different between cohorts, we did not conduct multivariate analysis to identify a hierarchy of variables, and this data may be more indicative of the different reasons for utilization. Finally, this clinical outcome analysis only considered 2-year minimum follow-up, and additional, longer term follow-up is necessary.

Significance: In conclusion, this large-scale clinical outcome study of 1,402 rTSA patients using two different size glenoid designs demonstrates that excellent results and a low revision rate can be achieved with each rTSA glenoid design style, though some differences in patient selection and utilization were observed.

Table 1. Comparison of Demographics and Comorbidities between rTSA patients with a small-size and a standard size rTSA glenoid

rTSA Design Cohort	Gender	Surgery on Dominant Hand?	Age (yrs)	Height (in)	Weight (lbs)	BMI	Prev. Shoulder Surgery	OA Diagnosis	RCT Diagnosis	CTA Diagnosis	No comorbidity	Heart Disease	Diabetes
Small rTSA	91.0% F	61.1%	70.6 ± 7.8	63.7 ± 3.3	171.7 ± 41.0	29.8 ± 6.7	30.2%	40.8%	33.7%	29.1%	20.6%	12.1%	14.7%
Standard rTSA	44.6% F	59.0%	71.0 ± 7.6	67.0 ± 0.5	190.9 ± 44.3	29.8 ± 5.9	26.4%	48.5%	29.5%	34.6%	22.2%	14.7%	18.3%
P Value	**<0.0001**	0.4536	0.3358	**<0.0001**	**<0.0001**	0.8502	0.1501	**0.0080**	0.1200	**0.0466**	0.5104	0.1956	0.1017

Table 2. Comparison of Operative & Implant Parameters between rTSA patients with a small-size and a standard size rTSA glenoid

rTSA Design Cohort	Subscap-ularis Repair?	Computer Navigation?	Blood Loss (cc)	Cemented Humeral Stem?	Short Humeral Stem?	Humeral Stem Diameter (mm)	Glenosphere Diameter (mm)	Constrained Humeral Liner?	Humeral Liner/Tray Offset (mm)	Augmented Baseplate Usage?	Expanded Glenosphere Usage?	# of Baseplate Screws
Small rTSA	37.4%	38.1%	170	7.6%	55.6%	8.9 ± 2.3	36.9 ± 1.7	1.2%	0.7 ± 1.6	41.4%	5.7%	3.6 ± 0.6
Standard rTSA	40.0%	42.7%	177	4.2%	51.9%	9.7 ± 2.8	40.0 ± 2.3	1.8%	0.9 ± 1.6	44.7%	10.2%	3.2 ± 0.8
P Value	0.3628	0.1058	0.2178	**0.0090**	0.2071	**<0.0001**	**<0.0001**	0.3751	0.3070	0.2435	**0.0068**	**0.0047**

Table 3. Comparison of rTSA Clinical Outcomes for Patients with Small-Size and Standard-Size rTSA Glenoid Designs

Timepoint	rTSA Design Cohort	Abduction	Forward Elevation	IR Score	Ext. Rotation	VAS Pain	Global Shoulder Function	Constant	ASES	SAS
Pre-op	Small rTSA	88.4 ± 44.3	98.3 ± 44.2	2.8 ± 1.9	26.2 ± 20.8	6.2 ± 2.2	4.3 ± 2.3	33.9 ± 14.5	36.9 ± 17.0	47.1 ± 14.2
	Standard rTSA	87.8 ± 42.5	96.6 ± 42.0	3.0 ± 1.8	23.7 ± 20.2	6.0 ± 2.3	4.2 ± 2.0	37.1 ± 15.1	38.3 ± 16.1	47.8 ± 12.8
	P Value	0.8152	0.5059	**0.0335**	**0.0490**	0.0682	0.6807	**0.0169**	0.1632	0.3868
2yr min	Small rTSA	133.3 ± 32.7	145.3 ± 28.3	3.7 ± 1.7	41.6 ± 16.9	1.2 ± 2.0	8.5 ± 1.8	65.0 ± 14.8	82.4 ± 17.3	74.7 ± 11.3
	Standard rTSA	134.5 ± 31.4	144.5 ± 27.0	3.8 ± 1.7	39.6 ± 17.7	1.1 ± 2.0	8.3 ± 1.9	66.4 ± 14.7	84.1 ± 17.8	74.9 ± 11.9
	P Value	0.5667	0.6722	0.1900	0.0744	0.6730	**0.0463**	0.2883	0.1173	0.7456
Improve	Small rTSA	49.0 ± 42.6	49.6 ± 41.7	1.0 ± 2.3	16.1 ± 22.7	5.1 ± 2.8	4.2 ± 2.7	32.1 ± 16.4	45.7 ± 21.1	28.2 ± 16.3
	Standard rTSA	50.7 ± 43.4	50.1 ± 41.5	0.7 ± 2.1	15.7 ± 21.4	4.9 ± 2.9	4.0 ± 2.7	28.1 ± 18.1	45.8 ± 22.1	27.1 ± 15.5
	P Value	0.5572	0.8685	0.0819	0.7756	0.1938	0.3587	**0.0318**	0.9526	0.3552