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Surgical and patient factors associated with baseplate failures after reverse shoulder arthroplasty: a study by the ASES Complications of RSA Multicenter Research Group

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ABSTRACT

Background: Baseplate failure is a rare but serious complication following reverse shoulder arthroplasty (rTSA), often leading to poor outcomes and revision surgery. Existing studies are limited by small samples or single-center designs. This multicenter study aimed to identify surgical, implant, and patient-related risk factors for baseplate failure after rTSA.

Methods: A multicenter, retrospective study was conducted across 15 U S. institutions involving 24 ASES surgeons. Patients who underwent rTSA from June 2013 to May 2019 with a minimum 3-month follow-up were included. Study parameters were established using the Delphi method. Patients with confirmed baseplate failure were compared to those without using univariate and multivariable logistic regression analyses. Failure was defined radiographically as gross baseplate shift or hardware breakage.

Results: Among 5,049 cases, 83 (1.6%) experienced baseplate failure at a median of 72 weeks post-surgery. Most failures (76%) were atraumatic; 12% were traumatic, and 12% had an unknown mechanism. Radiographs showed hardware breakage in 68.7% of the failures—33.3% involved central screw/post fractures and 86.0% involved peripheral screw fractures. Baseplate shift occurred in 78.3% of cases. Independent predictors of failure included revision arthroplasty (OR = 4.57; $P < .001$), use of bone graft (OR = 2.81; $P < .001$), and total glenoid-sided lateral offset (OR = 1.08; $P = .002$). Central screw fixation reduced failure risk (OR = 0.55; $P = .014$). In primary rTSA, bone grafting (OR = 4.42; $P < .001$) and lateral offset (OR = 1.07; $P = .046$) were significant predictors. In revision rTSA, only bone grafting remained significant (OR = 3.75; $P < .001$). Allograft use led to higher failure rates than autograft (14.7% vs 3.9%; $P = .001$).

Conclusion: Revision surgery, bone grafting (especially allografts), and increased lateral offset were significantly associated with higher odds of baseplate failure after rTSA. Central screw fixation appears protective. Most failures were atraumatic, underscoring the importance of achieving stable bone ingrowth. These findings may inform surgical planning and patient counseling regarding factors associated with increased failure risk.

Level of evidence: Level III; Retrospective Cohort Comparison; Prognosis Study

Keywords: Baseplate failure; reverse shoulder arthroplasty; multicenter; hardware; implant; risk factors

Reverse shoulder arthroplasty (rTSA) is being used with increasing frequency for a broader range of shoulder pathology. As the clinical indications expand and rTSA becomes more widely utilized, the number of patients experiencing complications of rTSA are expected to increase, necessitating further research into the causes of these complications.[3,6,9] Glenoid baseplate failure, defined as hardware failure or a gross shift in implant position, is an uncommon, but serious concern after rTSA. Early rTSA baseplates demonstrated high rates of failure, but in recent years, improvement in implant design and surgical techniques have led to improved outcomes.[9,12,25,26] Recent studies have demonstrated a baseplate failure rate between 1% and 2% with variation depending on patient and surgical factors.[22,37] Most baseplate failures typically occur between 12 and 19 months postoperatively.[2,19,26] Baseplate failure can result in poor clinical outcomes and typically necessitates revision rTSA, which have higher rates of complications and may undergo recurrent failure and re-revision.[6,18,19,23,35] Given the severity of these potential consequences, it is important to understand the predictors of baseplate failure.

Current literature pertaining to the risk factors for baseplate failure is limited by single-surgeon design with smaller sample sizes and heterogeneous inclusion and exclusion criteria. Higher quality studies involving larger cohorts are needed to provide a greater understanding of the patient-specific and surgical risk factors for baseplate failure. Thus, the purpose of this study is to identify surgical, implant, and patient factors contributing to baseplate failure following rTSA in a large multi-center cohort.

Methods

Study design

A multicenter, retrospective study was performed utilizing data collected for patients who underwent rTSA from June 2013 to May 2019 from 15 U S. institutions. Clinical follow-up was defined as the time from index rTSA to the most recent in-person postoperative clinic visit documented in the medical record, with a minimum required follow-up of 3 months for inclusion. This study involved patients of 24 members of the American Shoulder and Elbow Surgeons (ASES) who contributed to the Delphi process to determine inclusion and exclusion criteria, study definitions, and variables of interest. In all, 75% agreement among surgeons contributed to a consensus for parameters of this study. The entire group was presented with aggregate results and individual written responses prior to distribution of each iterative survey. There was no contributory attrition throughout the entire process from participant surgeons. To mitigate bias, anonymity was preserved throughout the entire process, with results aggregated and open-ended responses or comments blinded. Patients who underwent primary or reverse rTSA with a minimum 3-month clinical follow-up were eligible for this study. The primary outcome of interest was to determine which patient characteristics correlated with baseplate failure. A secondary outcome of interest was to determine which surgical or implant factors correlated with baseplate failure. Incidences of baseplate failure at clinical follow-up were identified through registry and chart review along with the type of treatment of the associated failure (revision, benign neglect, other). Baseplate failure was defined as a gross shift of the baseplate component or hardware breakage, confirmed radiographically by X-ray or computed tomography (CT) scan.

Patient characteristics that were collected for statistical analysis included sex, age, BMI, follow-up duration (months), American Society of Anesthesiologists (ASA) comorbidity score >2, comorbidities, such as immunosuppressants, osteoporosis, presence of inflammatory arthritis (IA), diabetes, smoking status, prior ipsilateral shoulder surgery, and the following primary diagnoses: glenohumeral osteoarthritis (GHOA), cuff tear arthritis (CTA), massive cuff tear (MCT) without GHOA, failed arthroplasty, and other. For those patients undergoing a revision arthroplasty, the type of revision (anatomic total shoulder replacement [aTSA] to rTSA, hemiarthroplasty to rTSA or rTSA to rTSA) was also collected. The glenoid components determined to be clinically relevant were lateral offset (LO) (mm) of the baseplate, use of bone graft and amount of LO (mm) from the graft, type of bone graft (structural versus non-structural and allograft versus autograft), metallic wedge (half or full), use of an augmented baseplate, type of central fixation (screw or peg/post), number of peripheral screws, utilization of superior baseplate screws, baseplate surface (overgrowth or ingrowth), central boss, glenosphere diameter (mm), total amount of LO (mm), eccentric glenosphere, and total glenoid-sided LO (mm). For the purposes of this study, "metallic wedge" referred to a modular metal augmentation added to the baseplate to address glenoid bone loss or version correction, whereas an "augmented baseplate" was defined as a baseplate with an integrated, monoblock design incorporating angular or volumetric correction as part of the implant itself (eg, posterior or superior augments). The humeral components determined to be clinically relevant were final neck shaft angle of the construct, polyethylene insert type (constrained or nonconstrained), polyethylene thickness (mm), spacer (thickness [mm]), and total humeral sided LO (mm).

Statistical analysis

Data were analyzed for normality and appropriate parametric or nonparametric testing was performed on the data. Data were analyzed as mean and standard deviation or

Table I – Nonmodifiable patient characteristics

Parameters	N	No baseplate failure	Baseplate failure	P value
		N = 4,966	N = 83	
Sex	5,049			
Male		2057 (41.4%)	52 (62.7%)	<.001*
Female		2909 (58.6%)	31 (37.3%)	
Age	3,745	70.4 ± 8.5	67.4 ± 9.9	.007*
BMI (kg/m2)	3,735	30.2 ± 6.7	30.3 ± 6.3	.943
Follow-up Duration (months)	3,745	7.3, 12.8, 25.0	12.2, 24.0, 36.0	<.001*
ASA Comorbidity Score >2	5,032	2631 (53.1%)	53 (64.6%)	.037*
Comorbidities				
Immunosuppresants†	4,442	497 (11.4%)	11 (13.4%)	.694
Osteoporosis	5,048	647 (13.0%)	8 (9.6%)	.455
Presence of IA	5,046	497 (10.0%)	12 (4.5%)	.250
Diabetes‡	5,047	1031 (20.8%)	12 (14.5%)	.204
Smoking	4,803			
Never		2665 (56.4%)	43 (55.1%)	.975
Former		1708 (36.1%)	29 (37.2%)	
Current		352 (7.4%)	6 (7.7%)	
Prior Ipsilateral Shoulder Surgery	5,044	1637 (33.0%)	51 (61.4%)	<.001*
Primary Diagnosis	5,049			
GHOA		1385 (27.9%)	23 (27.7%)	
CTA		1883 (37.9%)	17 (20.5%)	
MCT without GHOA		480 (9.7%)	2 (2.4%)	<.001*
Failed Arthroplasty (revision)		423 (8.5%)	35 (42.2%)	
Other		795 (16.0%)	6 (7.2%)	

BMI, body mass index; *ASA*, American Society of Anesthesiologists; *IA*, inflammatory arthritis; *GHOA*, glenohumeral osteoarthritis; *CTA*, rotator cuff tear arthropathy; *MCT*, massive rotator cuff tear.
Q1, M, Q3 represents first quartile, median, and third quartile.
* Denotes statistical significance; n (%) represents count and frequency; x ± s represents mean and standard deviation.
† Immunosuppresants used within three months of surgery.
‡ Diabetes types I and II aggregated into one group for analysis.

number of patients for quantitative data, and as percentages for continuous or categorical variables. Patient demographics and other selected variables were compared for cohorts of baseplate failures, and those without baseplate failures. Categorical variables were analyzed using Pearson's chi-squared tests and continuous variables were analyzed with Wilcoxon signed-rank tests. Multivariable binary logistic regression analysis was used to determine patient and surgical factors that were predictive of baseplate failure. Factors included in the regression models were selected based on a consensus-driven factor order determined through the Delphi method involving all participating surgeons, ensuring clinical relevance and consistency across analyses. An initial regression model included all patients to assess overall predictors of baseplate failure. Subsequently, separate multivariable logistic regression models were performed for primary rTSA and revision rTSA cohorts to identify factors independently associated with failure within each group. Results were presented as odds ratios (ORs) with 95% confidence intervals (CIs). Wald statistics were generated, and ANOVA plots were used to determine the relative strengths of predictor variables for baseplate failures. Statistical analysis was performed using open-source R statistical software (R Foundation for Statistical Computing, Vienna, Austria). Multivariable models were fit using the rms package [Ref- FE HJ. rms: Regression Modeling Strategies. https://cran.r-project.org/web/packages/rms/].

Results

Patient characteristics

The final cohort included 5049 patients with 83 (1.6%) experiencing a baseplate failure. There was a mean follow-up of 19.9 ± 15.9 months (range: 3-94 months). The average age was 70.3 ± 8.5 years, and 58.2% of patients were female (n = 2,940). Prior ipsilateral shoulder surgery was performed on 34% of the patients (n = 1724). The primary diagnosis of patients undergoing rTSA included glenohumeral osteoarthritis (28%, n = 1,408), rotator cuff tear arthropathy (38%, n = 1900), massive rotator cuff tear without glenohumeral arthritis (9.5%, n = 482), and failed arthroplasty (revision) (9.1%, n = 458).

Patient-specific variables

Univariate analysis revealed statistically significant differences between the no baseplate failure (NBF) cohort, and the baseplate failure (BF) cohort in categories including male sex (41.4% males NBF versus 62.7% males BF, $P < .001$), age (70.4 ± 8.5 NBF versus 67.4 ± 9.5 BF, $P = .007$), follow-up duration (months) (median, 12.8 NBF versus 24.0 BF, $P < .001$), ASA comorbidity score of >2 (53.1% BPF versus 64.6%, $P = .037$), prior ipsilateral shoulder surgery (33.0% BPF versus 61.4% BF, $P < .001$), and a primary diagnosis of massive rotator

Table II – Modifiable surgical elements

Implant Components	Parameters	N	No Baseplate Failure N = 4,966	Baseplate Failure N = 83	P Value
GLENOID COMPONENTS	Baseplate Lateral Offset (mm)	4,934	0.5 ± 0.9	0.3 ± 0.8	.093
	Bone Graft	5,042	409 (9.0%)	28 (34.1%)	<.001*
	Amount of LO (mm)	172	9.8 ± 4.5	10.4 ± 5.5	.676
	Metal Wedge	5,040	111 (3.0%)	0 (0%)	<.001*
	Metal Wedge Type	111			
	Half		40 (36.0%)	0 (0%)	<.001*
	Full		71 (64.0%)	0 (0%)	
	Augmented Baseplate	5,040	596 (13.5%)	27 (4.3%)	<.001*
	Central Fixation	5,039			
	Screw		3,050 (61.5%)	33 (40.2%)	<.001*
	Peg/Post		1907 (38.5%)	49 (59.8%)	
	Number of Peripheral Screws	5,020	3.5 ± 0.8	3.8 ± 0.8	.003*
	Superior Screws Used	5,030	4,823 (97.5%)	77 (93.9%)	.095
	Baseplate Surface	4,950			
	Ongrowth		992 (20.3%)	18 (21.7%)	.170
	Ingrowth		3,875 (79.7%)	65 (78.3%)	
	Central Boss	5,019	2,199 (44.5%)	45 (54.2%)	.100
	Glenosphere Diameter (mm)	5,030	36.4 ± 3.1	37.8 ± 3.6	<.001*
	Amount of LO (mm)	5,048	2.7 ± 3.2	3.4 ± 2.9	.035*
	Eccentric Glenosphere	5,041	1,139 (23.0%)	6 (7.5%)	.002*
	Total Glenoid-Sided LO (mm)	5,002	3.9 ± 3.6	7.2 ± 6.1	<.001*
HUMERAL COMPONENTS	Neck-Shaft Angle (°)	5,041	144 ± 7	144 ± 6	.560
	Polyethylene Insert Type	5,041			
	Constrained		161 (3.2%)	8 (10.0%)	.003*
	Nonconstrained		4,800 (96.8%)	72 (90.0%)	
	Polyethylene Thickness (mm)	5,041	2.3 ± 3.1	2.3 ± 3.3	.938
	Spacer	5,043	164 (3.3%)	6 (7.5%)	.080
	Thickness (mm)	170	7.2 ± 2.9	10.0 ± 4.5	.186
	Total Humeral-Sided LO (mm)	4,996	3.4 ± 4.8	3.4 ± 5.5	.986

°, degrees; *mm*, millimeter; *LO*, lateral offset.
* Denotes statistical significance; n (%) represents count and frequency; x ± s represents mean and standard deviation.

cuff tear without glenohumeral osteoarthritis (9.7% NBF versus 2.4% BF, $P < .001$) (Table I).

Modifiable surgical elements

Univariate analysis of both glenoid and humeral implant-related factors found statistically significant differences between the NBF cohort and the BF cohort. These parameters include use of bone graft (9.0% NBF versus 34.1% BF, $P < .001$), metal wedge (3.0% NBF versus 0.0% BF, $P < .001$), augmented baseplate (13.5% NBF versus 4.3% BF, $P < .001$), central fixation (screw; peg/post) (61.5%; 38.5% NBF versus 40.2%; 59.8% BF, $P < .001$), number of peripheral screws (3.5 ± 0.8 NBF versus 3.8 ± 0.8 NBF $P = .003$), glenosphere diameter (mm) (36.4 ± 3.1 NBF versus 37.8 ± 3.6, $P < .001$), eccentric glenosphere (23.0% NBF versus 7.5% BF, $P = .002$), and total glenoid-sided lateral offset (3.9 ± 3.6 NBF versus 7.2 ± 6.1, $P < .001$). One additional statistically significant difference was found for humeral components, which was polyethylene insert type (constrained; nonconstrained) (3.2%; 96.8% NBF versus 10.0%; 90.0%, $P = .003$). (Table II).

Revision and bone graft types

A univariate sub-analysis of 4,456 cases displayed 78 patients (1.7%) experiencing a baseplate failure with a significantly higher failure rate observed in patients undergoing revision arthroplasty in comparison to primary arthroplasty (9.2% revision NBF versus 44.9% revision BF, $P < .001$). Revision type did not significantly influence baseplate failure rates among the subcategories: total shoulder arthroplasty (TSA) converted to reverse shoulder arthroplasty (rTSA), hemiarthroplasty converted to rTSA, or rTSA revised to rTSA (8.3% vs 5.5% vs. 7.6%, $P = .666$). Univariate analysis again revealed statistically significant differences between the no baseplate failure cohort and the baseplate failure cohort in patients with a bone graft (7.8% NBF versus 33.3% BF, $P < .001$). Among bone grafts, allografts demonstrated a significantly higher failure rate (16.3%) compared to autografts (3.8%, $P = .002$). Whether the graft was structural versus nonstructural showed no significant difference in failure rates (7.0% vs 7.7%, $P = .519$) (Table III).

Baseplate failure events

The median time of baseplate failure since surgery was 72 weeks (16.6 months), with 40 weeks and 137 weeks as the first and third quartiles respectively. The nature of the failures included 10 traumatic events (12.0%), 63 atraumatic events (75.9%) and 10 unknown causes (12.0%). In 68.7% of patients there was hardware breakage (n = 57). One-third of these hardware failures included central screw/post/peg fracture

Table III – Modifiable surgical elements

Parameters	N	No baseplate failure N = 4,456	Baseplate failure N = 78	Failure rate	P value
Revision (Ref: Primary)	447	412 (9.2%)	35 (44.9%)	7.8%	<.001*
aTSA > rTSA	205	188	17	8.3%	.666
Hemi > rTSA	109	103	6	5.5%	
rTSA > rTSA	120	111	9	7.6%	
Bone Graft	374	348 (7.8%)	26 (33.3%)	7.0%	<.001*
Structural	257	238	19	7.4%	>.999
Non-Structural	66	61	5	7.6%	
Allograft	116	99	17	14.7%	.001*
Autograft	205	197	8	3.9%	

TSA, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *Hemi*, hemiarthroplasty.
* Denotes statistical significance; n (%) represents count and frequency.

Table IV – Baseplate failure events

Parameter	N	Total N = 83
Time since surgery (weeks); Q1, M, Q3	83	40, 72, 137
Nature of Failure; n (%)	83	
Traumatic		10 (12.0%)
Atraumatic		63 (75.9%)
Unknown		10 (12.0%)
Radiographic Analysis		
Hardware Breakage; n (%)	83	57 (68.7%)
Central Screw/Post/Peg Fracture; n (%)*	57	19 (33.0%)
Peripheral Screw Fracture; n (%)*	57	49 (86.0%)
Gross Shift of Baseplate Component; n (%)	83	65 (78.3%)

Q1, M, Q3 denotes first quartile, median, third quartile; n (%) denotes count and frequency.
* Frequencies of central and peripheral fixation fractures calculated using "positive hardware breakage" n as the denominator.

(n = 19), and 86.0% were peripheral screw fractures (n = 49). Additionally, 78.3% of patients had gross shift of the baseplate component (n = 65) (Table IV).

Predictive factors for baseplate failure in overall cohort

After adjusting for potential confounding factors through multivariable logistic regression, factors independently associated with baseplate failure were found to be revision rTSA (ref: primary) (OR = 4.57; 95% CI = 2.77-7.57; $P < .001$), glenoid-sided bone graft (OR = 2.81; 95% CI = 1.57-5.17; $P < .001$), and total glenoid-sided lateral offset (OR = 1.08; 95% CI = 1.03-1.13; $P = .002$). Central screw fixation was found to be independently associated with a decreased risk of baseplate failure (ref: peg/post) (OR = 0.55; 95% CI = 0.34-0.88; $P = .014$) (Table V).

Predictive factors for baseplate failure in primary rTSA

After isolating all primary rTSA cases and adjusting for potential confounding factors through multivariable logistic regression, factors independently associated with baseplate failure in primary rTSA were found to be glenoid-sided bone graft (OR = 4.42; 95% CI = 2.18-8.95; $P = <0.001$), and total glenoid-sided lateral offset (OR = 1.07; 95% CI = 1.00-1.14; $P = .046$) (Table VI).

Predictive factors for baseplate failure in revision rTSA

After isolating all revision rTSA cases, multivariable logistic regression identified glenoid-sided bone graft (OR = 3.75; 95% CI = 1.81-7.80; $P < .001$) as an independent predictor of baseplate failure. (Table VII).

Discussion

This large multi-center study demonstrated that revision shoulder arthroplasty, utilization of a glenoid bone graft, specifically allograft, and total glenoid-sided lateral offset are risk factors associated with baseplate failure following rTSA. Furthermore, baseplate constructs with central screw fixation are associated with a significantly decreased risk of baseplate failure in comparison to central fixation with a post/peg. Understanding patient, surgical, and implant-related factors for baseplate failure can be utilized to optimize component fixation and ingrowth in at-risk patients.

Patient characteristics

Our data were associated with a nearly 5x increased odds of baseplate failure for patients undergoing a revision arthroplasty, which is consistent with current literature. A recent systematic review from Welch et al[43] on 1,041 shoulders found a high overall complication rate of 23.4% in the revision setting, with glenoid component loosening (n = 44, 6.0%) being the most common complication. A retrospective comparison of primary rTSA versus revision rTSA by Saltzman et al[36] found a 69% complication rate following revision rTSA compared to 25% following primaries. Multivariable regression revealed that revision status was the most significant predictor of overall complication rate.[36] Revision procedures inherently carry greater technical challenges and risks due to altered anatomy and compromised bone stock, particularly in revisions of aTSA to rTSA.[3,10,33,39,42] Our findings regarding the increased risk of glenoid component loosening in the setting of revision arthroplasty demonstrate the inherent challenges associated with revisions and highlight the importance of mitigating failure through appropriate surgical technique and improvements in implant design and materials. Our sub-

Table V – Predictors of baseplate failure following rTSA

Parameter	Odds ratio	Confidence interval		P value
		2.5	97.5	
Revision (Ref: Primary)	4.57	2.77	7.57	<.001*
Inflammatory Arthritis†	1.69	0.88	3.26	.115
Osteoporosis	0.65	0.30	1.41	.277
Glenoid-Sided Bone Graft	2.81	1.52	5.17	<.001*
Age (in years)‡	0.98	0.96	1.00	.075
Total Glenoid-Sided Lateral Offset (in mm)‡	1.08	1.03	1.13	.002*
On-Growth Baseplate Surface (Ref: In-growth)	0.97	0.55	1.71	.914
Central Screw Fixation (Ref: Peg/Post)	0.55	0.34	0.88	.014*

* Statistical significance with alpha risk of 0.05.
† Presence of inflammatory arthritis regardless of primary diagnosis.
‡ Odds ratios for continuous variables represent the change per unit increase of the variable; mm, millimeter.

Table VI – Predictors of baseplate failure following primary rTSA

Parameter	Odds ratio	Confidence interval		P value
		2.5	97.5	
Inflammatory Arthritis†	1.99	0.94	4.20	.072
Osteoporosis	0.65	0.25	1.70	.383
Glenoid-Sided Bone Graft	4.42	2.18	8.95	<.001*
Age (in years)‡	0.98	0.95	1.01	.262
Total Glenoid-Sided Lateral Offset (in mm)‡	1.07	1.00	1.14	.046*

* Statistical significance with alpha risk of 0.05.
† Presence of inflammatory arthritis regardless of primary diagnosis.
‡ x Odds ratios for continuous variables represent the change per unit increase of the variable; mm, millimeter.

Table VII – Predictors of baseplate failure following revision rTSA

Parameter	Odds ratio	Confidence interval		P value
		2.5	97.5	
Osteoporosis	0.94	0.27	3.34	.277
Inflammatory Arthritis†	0.98	0.28	3.43	.977
Glenoid-Sided Bone Graft	3.75	1.81	7.80	<.001*

* Statistical significance with alpha risk of 0.05.
† Presence of inflammatory arthritis regardless of primary diagnosis.

analysis of failure rates by revision type found no significant differences among common revision arthroplasty types, including aTSA to rTSA, hemiarthroplasty to rTSA, and rTSA to rTSA. However, our findings are limited by the small event rate, preventing definitive conclusions. Notably, our results differ from those of Bartels et al,[1] who reported a 17% glenoid mechanical failure rate for revisions to rTSA following failed aTSA, compared to the 8.3% failure rate observed in our cohort. Holcomb et al[18] investigated 676 revision rTSAs for failed rTSA due to baseplate failure, reporting a 6.5% failure rate, which closely aligns with our findings. Similarly, a systematic review by Welch et al[43] analyzed 728 shoulders undergoing revision rTSA for failed aTSA or hemiarthroplasty, identifying a 7.4% failure rate of the glenoid or humeral component. These findings underscore the need for further research with larger cohorts to better understand failure patterns by revision type and reconcile the discrepancies observed across studies. Findings from the Australian Orthopaedic Association National Joint Replacement Registry revealed that the use of highly crosslinked polyethylene in aTSA is associated with lower failure rates, highlighting how technological advancements in aTSA can help reduce the need for revisions to rTSA.[34]

Surgical factors

The use of bone graft and total glenoid-sided lateral offset were both independently associated with baseplate failure. In our multivariable regression model, each 1 mm increase in total glenoid-sided lateral offset was associated with an 8% increase in the odds of baseplate failure.

This finding suggests that greater glenoid-sided lateralization may increase mechanical stress at the bone-implant interface, as evidenced by an 8% increase in failure odds for each millimeter of lateral offset. Surgeons should be mindful of the cumulative lateralization when selecting implants or planning reconstruction strategies.

The use of bone graft on the glenoid has been associated with baseplate loosening and failure.[17,23,41] Despite controlling for confounding factors in the multivariable regression model, the challenges associated with addressing significant glenoid deformity and bone loss likely serve as surrogates for increased risk of baseplate failure in patients who require bone grafting.[30] Our sub-analysis demonstrated that bone grafting was a significant predictor of baseplate failure in both primary and revision rTSA. In primary rTSA, glenoid-sided bone graft was associated with a more than fourfold increased risk of failure, while in revision rTSA, it remained a strong predictor, nearly tripling the odds of failure. These findings highlight the ongoing challenges of managing glenoid bone loss and emphasize the importance of careful preoperative planning and alternative fixation strategies when extensive bone grafting is required.

The association between bone grafting and baseplate failure has been demonstrated previously in several studies. Wagner et al[41] found that glenoid loosening and implant failure are more common in shoulders treated with bone-grafting at the time of revision, with decreased survival rates compared to those treated without a bone graft. Ho et al[17] reported on 44 patients who underwent rTSA with structural bone grafting for glenoid bone defects and found a high radiographic failure rate of 25% at a minimum 1-year follow-up. Additionally, a higher rate of graft resorption was correlated with those who experienced radiographic failure.[17] Bitzer et al[2] also found that the use of a bone graft increased the risk of baseplate loosening by nearly 7x compared to those not receiving a bone graft. Our sub analysis of bone graft type revealed a significantly higher failure rate in patients treated with allografts compared to autografts, while no differences in failure rates were observed between structural and nonstructural bone grafts. However, the small event rate limits the ability to draw definitive conclusions from these findings. The existing literature on bone grafting outcomes in the context of rTSA is limited. However, prior studies provide mixed findings. Castricini et al[7] reported a 20% complication rate in patients receiving allografts in primary rTSA, consistent with our results. Conversely, Jones et al[20] found no differences in clinical outcomes or complication rates between autografts and allografts in rTSA. Similarly, Lopiz et al[27] observed no statistically significant differences in graft incorporation or complication rates between autografts and allografts. While many studies do not differentiate between structural and nonstructural grafts, Mahylis et al[29] specifically compared outcomes in patients with structural autografts for severe glenoid bone loss to those with nonstructural allografts for less severe bone loss in revision rTSA, finding no significant differences in outcomes between the 2 cohorts. These findings, along with the results of this study, highlight the need for further investigation with greater numbers into the optimal bone graft type and its impact on outcomes in rTSA, while emphasizing the importance of caution and the potential consideration of alternative strategies when addressing glenoid deformity. Biomechanical studies have shown that metal baseplate augmentation results in significantly reduced micromotion, indicating more secure baseplate fixation.[8] Metal augmentation has also clinically been shown to lead to significantly lower failure rates compared to bony augmentation in a recent systematic review on complications after rTSA.[32]

While the odds ratio for glenoid-sided lateral offset appears smaller on a per-millimeter basis compared to categorical variables, its cumulative impact may be substantial, particularly in cases with substantial lateralization. This finding reinforces the biomechanical relevance of glenoid offset and its potential role in implant design considerations. Glenoid-sided lateralization can be achieved through numerous methods including lateralizing through the glenosphere,[13,14] lateralizing the baseplate,[21,40] or increasing the length of the scapular neck with a bone graft.[4,5] Although increased lateralization has been shown to improve range of motion and mitigate impingement, it also increases the force required for the deltoid to perform abduction and places the acromion as well as the glenoid implant under substantial shear forces.[11,16,31,44,45] In a biomechanical study by Harman et al,[14] increased lateral offset was found to significantly increase the magnitude of motion during physiologic loading, further supporting a potential link between lateralization and glenoid loosening. This finding is supported by other recent systematic reviews which have also found that lateralized glenospheres result in a higher rate of implant failure compared to non-lateralized glenospheres.[15,24,32] Thus, despite the potential benefits of glenoid-sided lateralization, in at-risk patients such as during revision arthroplasty with compromised glenoid bone stock, surgeons should exercise caution and avoid excessively lateralizing on the glenoid.

The method of central baseplate fixation was found to be associated with baseplate failure. Baseplates with central screw fixation were associated with a decreased risk of failure. This protective effect may be due to the superior time-zero mechanical stability provided by screws, which can offer better purchase in compromised bone and distribute loads more effectively. The impact of using a central screw versus a central peg varies in the literature. Torkan et al[38] found similar results in a biomechanical study with a central peg generating 358% more micromotion compared to central screw fixation ($P < .001$). Lung et al[28] also found a shorter central peg leading to increased micromotion. However, other studies comparing multiple types of central fixation methods have shown no significant differences in micromotion between any of the designs. While the use of a central screw appears to offer superior initial mechanical stability and reduced risk of failure compared to a peg or post, the variability in findings across different studies suggests that further research is needed to definitively determine the optimal method of central fixation in shoulder arthroplasty.

The identification of these modifiable and non-modifiable risk factors has several clinical implications. The heightened risk associated with revision arthroplasty and the use of bone graft for glenoid augmentation should be understood. Surgeons should discuss the increased likelihood of complications with patients undergoing revision procedures and those requiring bone grafting, setting realistic expectations and exploring alternative strategies where feasible. Moreover, the protective role of central screw fixation suggests that surgical techniques and implant designs that enhance fixation stability should be favored, particularly in high-risk cases. The adoption of screws over pegs or posts for central fixation could be a practical strategy to reduce baseplate failures, contributing to improved patient outcomes.

The current study identifies factors predictive of baseplate failure, utilizing the largest single cohort of consecutive rTSA patients to our knowledge. Conducted through the collaboration of 15 institutions across the United States and involving cases from 24 different surgeons, this study benefits from a highly generalizable and heterogeneous cohort. Moreover, our analysis employed a multivariable logistic regression, which was appropriately fit to the data based on the available degrees of freedom, ensuring accurate results and minimizing the risk of overfitting.

This study does however have several limitations that should be noted. Despite the large patient cohort, the level of evidence is limited by the study's retrospective nature. Specifically, the surgical factors associated with a higher risk of baseplate failure may be confounded by their increased utilization among high-risk patients. The associations between bone graft use, lateral offset, and baseplate failure may partially be due to unmeasured differences in preoperative bone deficit severity rather than the surgical techniques alone. Additionally, the study was limited by the lack of standardized, quantitative assessment of glenoid bone loss and deformity across institutions. While surrogate variables such as glenoid grafting, augmented baseplates, and lateral offset were included, these do not fully capture the extent or pattern of bone loss, which may have influenced both implant selection and risk of baseplate failure. Another limitation of this study is the variability in implant systems, surgical techniques, and procedural volumes across participating centers. While this reflects real-world practice and enhances generalizability, a prospective study with a limited number of implants and more balanced representation across sites would better control for confounding variables and improve internal validity. Additionally, the number of cases contributed and the incidence of baseplate failure varied between institutions, potentially introducing institutional bias. Similarly, implant utilization lacked standardization due to contributions from multiple surgeons. Methodology criteria were decided through the Delphi technique with expert rTSA surgeons, but consensus was based on a 75% agreement threshold, possibly resulting in non-unanimous decisions. The minimum follow-up period for inclusion was 3 months, which may have led to missed failure and potential underrepresentation of the overall incidence of baseplate failure within the cohort. Given that the median time to baseplate failure in our cohort was 72 weeks, and prior literature reports that most failures occur between 12 and 19 months, it is likely that some delayed failures were not captured. As a result, the true incidence of baseplate failure may be underestimated in this analysis. Furthermore, vault loss parameters and characteristics were not explicitly measured, limiting the study's ability to assess their impact. Evaluation of glenoid and humeral offset was restricted to implant descriptors rather than radiographic measurements, such as the lateralization shoulder angle (LSA), deltoid shoulder angle (DSA), and lateral humeral offset (LHO). Another limitation is that we did not use an adjusted P-value to correct for multiple comparisons, as is done with the Bonferroni correction method. However, given that our study is retrospective without a-priori defined analyses and is purely exploratory rather than confirmatory for final decision making, we felt that it was not necessary to perform such corrections. Doing so can increase the chance for type 2 errors and be diminutive to the power of an analysis. Nonetheless, it remains possible that some of our significant results may be due to chance, and this exploratory work should serve as a pilot for future studies. Lastly, the study did not include tools to assess clinical outcomes in patients, such as patient-reported outcome measures or range of motion assessments, which would have been useful in comparing the final disposition of patients who experienced a baseplate failure to those who did not. While this study focused on radiographic definitions of failure, these metrics do not always correlate with a patient's lived experience or functional status. In particular, the absence of PROMs limits the ability to contextualize baseplate failure in terms of patient quality of life, especially in the revision setting where counseling patients on risk and expected outcomes is critical.

Conclusion

The strongest patient-related factor independently associated with baseplate failure was revision arthroplasty, while the strongest surgical factors were the utilization of a bone graft, specifically an allograft, and total glenoid-sided lateral offset. Bone graft utilization was a significant predictor of baseplate failure in both primary and revision rTSA, highlighting its impact on implant stability regardless of surgical setting. Baseplates with central screw fixation were associated with a lower risk of baseplate failure compared to other methods. The majority of failures were also atraumatic, suggesting a lack of ingrowth necessary for long-term stability. These modifiable and non-modifiable risk factors of baseplate failure following rTSA can be used to optimize preoperative patient counseling as well as surgeon decision-making at time of surgery.

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