Title:

What Factors are Associated with Instability after Endoprosthetic Reverse Total Shoulder Arthroplasty for Oncologic Reconstruction of the Proximal Humerus?

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Significance & Hypothesis/Techniques

Reverse total shoulder arthroplasty (rTSA) is increasingly used for oncologic reconstruction after proximal humeral resection because it can restore function without depending on an intact rotator cuff. However, instability remains a common postoperative complication, and data defining predictors of instability in this setting remain limited. The purpose of this study was to identify patient-, tumor-, and surgery-related factors associated with instability after endoprosthetic rTSA following oncologic proximal humeral resection.

Innovation

This study represents the largest reported multi-institutional analysis of instability after oncologic proximal humeral endoprosthetic rTSA. It is clinically innovative because it evaluates oncologic-specific risk factors, including revision reconstruction, postoperative infection, soft-tissue and implant-related variables, and shoulder co-surgeon involvement.

Approach (Materials & Methods)

We performed a retrospective multi-institutional cohort study of 141 patients undergoing oncologic resection and proximal humeral endoprosthetic reconstruction with rTSA at 6 tertiary centers from 2010–2024. Stable and unstable reconstructions were compared using univariate analyses, and multivariable logistic regression was used to identify independent risk factors for instability. Variables collected included age, sex, BMI, chemotherapy, revision status, resection length, deltoid insertion preservation, glenosphere size and offset, custom implant use, mesh reconstruction, cuff repair, liner constraint, rehabilitation protocol, diagnosis, soft-tissue mass, pathologic fracture, glenoid involvement, and axillary nerve involvement.

Results

A total of 141 patients were included, with a median follow-up of 18.6 months. Postoperative instability occurred in 21 patients (14.9%), with a median time to dislocation of 1.3 months; 75% of events occurred within 3 months of surgery.

Instability was treated definitively with closed reduction in 33% of cases (n=7). Fifty-two percent of patients (n=11) required open reduction with component revision, while 10% of cases (n=2) required open reduction without component revision. Long-term stability was ultimately achieved in 12 patients (57%). Seven patients (33%) experienced chronic instability, while 3 underwent explantation for chronic infection.

Higher body mass index was associated with increased instability risk (p=0.02). Revision reconstruction (i.e. prior failed oncologic reconstruction) (p=0.028) and use of custom implants (p=0.04) were associated with instability on univariate analysis. Prosthetic joint infection was strongly associated with subsequent instability (p=0.01), while no instability events occurred in cases performed with a fellowship-trained shoulder co-surgeon (p=0.044). Resection length, axillary nerve involvement, glenosphere size or offset, implant constraint, and deltoid insertion management were not associated with instability.

In multivariable analysis, elevated BMI and prosthetic joint infection remained independently associated with instability, whereas shoulder co-surgeon involvement was associated with lower observed instability risk (p<0.03).

Discussion & Impact

Instability after oncologic proximal humeral rTSA is common and occurs early, with most events arising in the first 3 postoperative months. Elevated BMI and prosthetic joint infection appear to meaningfully increase instability risk, while collaboration with a fellowship-trained shoulder surgeon may be protective. These findings have practical implications for preoperative counseling, multidisciplinary planning, surgical execution, and postoperative vigilance in this high-risk population. More broadly, the study helps distinguish instability risks that appear intrinsic to patient or complication profile from those that may be modifiable through operative planning and subspecialty collaboration.

Table 1: Comparison of patient demographic, surgical, and tumor characteristics in unstable versus stable endoprosthetic rTSA reconstruction.

	All rTSA		**Unstable**		**Stable**		**p-value***
All Centers (n, %)	141	100%	21	15%	120	85%	
Patient Characteristics							
Age (mean, std)	56.6	18.4	56.2	16.2	56.7	18.8	0.700
Female (n, %)	74	52%	11	52%	63	53%	0.999
BMI (mean, std)	30.2	7.8	35.3	10.4	29.3	6.9	**0.023**
Pre-op chemo (n, %)	42	30%	7	33%	35	29%	0.797
Post-op chemo (n, %)	53	38%	4	19%	49	41%	0.086
Surgical Characteristics							
Revision cases (n, %)	9	6%	4	19%	5	4%	**0.028**
Shoulder surgeon (n, %)	20	14%	0	0%	20	17%	**0.044**
Resection length (mean, std)	63.3	54.0	75.9	64.9	61.1	52.8	0.469
Deltoid insertion preserved (n, %)	103	73%	14	67%	89	74%	0.594

Glenosphere size (mean, std)	37.9	2.4	38.1	2.5	37.8	2.4	0.846
Glenosphere offset (mean, std)	1.7	2.3	2.2	3.5	1.7	2.0	0.892
Custom Implant (n, %)	6	4%	3	14%	3	3%	**0.043**
Mesh (n, %)	16	11%	3	14%	13	11%	0.708
Cuff Repair (n, %)	71	50%	11	52%	60	50%	0.999
Liner (n, %)							0.099
Constrained/Semi-Constrained	21	15%	6	29%	15	13%	
Locked Ring Constrained	3	2%	1	5%	2	2%	
Standard	116	82%	14	67%	102	85%	
Accelerated Rehab Protocol (<6 Weeks)	36		4	19%	32	28%	0.40
Tumor Characteristics							
Diagnosis (n, %)							0.820
Primary Bone Sarcoma	41	29%	5	24%	36	30%	
Soft Tissue Sarcoma	3	2%	1	5%	2	2%	
Benign Bone Tumor	7	5%	1	5%	6	5%	
Lymphoma/Leukemia	1	1%	0	0%	1	1%	
Multiple Myeloma	14	10%	2	10%	12	10%	
Metastatic Disease	75	53%	12	57%	63	53%	
Soft tissue mass (n, %)	82	58%	13	62%	69	58%	0.813
Pathological fracture (n, %)	84	60%	12	57%	72	60%	0.814
Glenoid involvement (n, %)	5	4%	1	5%	4	3%	0.559
Axillary nerve involved (n, %)	3	2%	0	0%	3	3%	0.999

*P-values compare unstable vs stable cohorts. Mann-Whitney U-tests were used to compare continuous variables. Fisher's exact tests were used to compare categorical variables. P-values < 0.05 were considered statistically significant and are bolded.

Table 2: Comparison of outcomes between unstable and stable endoprosthetic rTSA groups.

	All rTSA		**Unstable**		**Stable**		**p-value***
All Centers (n, %)	141	100%	21	15%	120	85%	
All Cause Reoperation (n, %)	39	28%	18	86%	21	18%	**<0.001**
Humeral-sided aseptic loosening	4	3%	1	5%	3	3%	0.479
Glenoid-sided aseptic loosening	1	1%	0	0%	1	1%	0.999
Periprosthetic fracture (n, %)	3	2%	0	0%	3	3%	0.999
Periprosthetic joint infection (n, %)	4	3%	3	14%	1	1%	**0.011**
Anterior Humeral Escape	3	2%	1	5%	2	2%	0.386
Local disease recurrence (n, %)	21	15%	2	10%	19	16%	0.740
Mechanical failure (n, %)	3	2%	1	5%	2	2%	0.386
Range of Motion at Final Follow Up							**0.022**

<45 degrees	22	16%	7	33%	15	13%	
45-90 degrees	48	34%	8	38%	40	33%	
>90 degrees	54	38%	3	14%	51	43%	
Missing/unknown	17	12%	3	14%	14	12%	
Duration of follow up (months)							0.667
Mean, STD	26.0	27.2	24.8	21.5	26.2	28.1	
Min	0.2		1.6		0.2		
Q1	4.6		6.6		4.4		
Median	18.6		16		18.8		
Q3	37.4		39.9		37.3		
Max	128.4		71.1		128.4		

*P-values compare unstable vs stable cohorts. Mann-Whitney U-tests were used to compare continuous variables. Fisher's exact tests were used to compare categorical variables. P-values < 0.05 were considered statistically significant and are bolded.

Table 3: A multivariable analysis of factors associated with instability following oncologic reconstruction of the proximal humerus.

Variables	**Comparison**	**Odds Ratio**	**Confidence Interval**	**p-value**
BMI ≥40	**BMI <40**	5.2	(1.4-18.9)	**0.02**
Revision	**Primary**	3.5	(0.5-20.8)	0.21
Shoulder Surgeon	**No Shoulder Surgeon**	0.01*	(0-0.76)	**0.03**
Custom Implants	**Standard Implants**	4.7	(0.6-32.2)	0.12
Prosthetic Joint Infection	**No Infection**	16.2	(1.5-365)	**0.02**

* Presence of a shoulder surgeon was statistically significant; however, in the logistic regression model the presence of no shoulder surgeons in the instability cohort rendered the model unstable and unable to provide an odds ratio.