Implant and Patient Factors Predictive of Acromial Stress Fractures after Reverse Shoulder Arthroplasty (RSA): A Study by the ASES Complications of RSA Multicenter Research Group

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INTRODUCTION:

Despite an increasing awareness of acromial stress fractures (ASFs) and scapular spine fractures (SSFs) as complications unique to reverse shoulder arthroplasty (RSA), data pertaining to the effect of implant design on their incidence remains conflicted. The purpose of this study was to identify implant and patient factors that are associated with the development of ASFs and SSFs in a large patient cohort.

METHODS:

A multi-center retrospective study was performed at 15 institutions, comprising 21 American Shoulder and Elbow Surgeons (ASES) members. Patients that underwent primary or revision RSA from June 2013 to May 2019 with a minimum of 3-month follow up were included. All contributing ASES members participated in the Delphi method, an iterative survey process requiring a minimum of 75% agreement, to determine study definitions and parameters. Only symptomatic ASFs/SSFs with confirmatory radiography or computed tomography were included. Radiographic data including lateralization shoulder angle (LSA), distalization shoulder angle (DSA), and lateral humeral offset (LHO) were collected at a 2:1 ratio of control to fracture and propensity score matched (Figure 1). Humeral implant design was only studied radiographically in order to minimize the potential for confounding due to variation in surgical technique. Multivariable logistic regression was performed to identify patient, implant, and radiographic variables associated with ASFs/SSFs.

RESULTS:

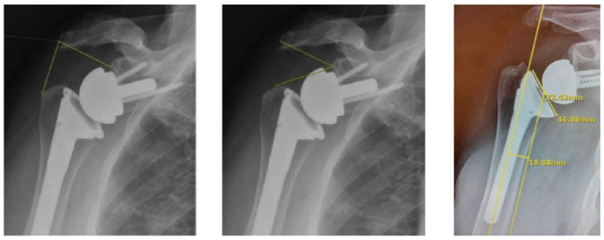
We identified 6,230 patients with an overall stress fracture incidence of 3.8% (n=239). The rates of ASFs and SSFs were 2.9% (n=180) and 0.9% (n=59), respectively. Patients with ASFs were found to have greater total glenoid lateral offset than those without fracture (mean ± SD; 4.6±3.8 vs. 4.0±3.4; $P = 0.021$). After multivariable adjustment, implant and patient factors independently predictive of ASFs were inflammatory arthritis (OR 2.19; $P < 0.001$), diagnosis of massive rotator cuff tear (OR 2.09; $P = 0.002$), osteoporosis (OR 2.00; $P < 0.001$), prior shoulder surgery (OR 1.84; $P < 0.001$), diagnosis of cuff tear arthropathy (OR 1.78; $P = 0.002$), female sex (OR 1.77; $P = 0.002$), increasing age (OR 1.60; $P = 0.021$), and increasing total glenoid lateral offset (OR 1.57; $P = 0.023$). Revision surgery was associated with a lower rate of ASF (OR 0.38; $P = 0.017$; reference: primary surgery) (Table 1). Factors independently associated with SSFs were female sex (OR 2.52; $P = 0.007$), and osteoporosis (OR 2.31; $P = 0.005$). Radiographic analysis demonstrated that a greater ΔLSA (OR 1.42; $P = 0.005$) was independently associated with a higher risk of stress fracture, whereas increased LHO (OR 0.74; $P = 0.031$) was protective. Distalization (ΔDSA) was not associated with stress fracture incidence (OR 0.94; $P = 0.635$) (Table 1).

DISCUSSION AND CONCLUSION:

Patient factors associated with poor bone density and rotator cuff deficiency appear to be the strongest predictors of ASFs after RSA. Implant factors, to a lesser degree, may also affect ASF incidence in at risk patients, as increased lateral humeral offset was found to be protective, whereas excessive glenoid sided and global lateralization were associated with higher fracture rates. The value of humeral-sided lateralization in respect to ASFs should be considered in the setting of

the known advantages of glenoid-sided lateralization, such as lower rates of scapular notching and impingement, when appraising various implant designs.

Figure 1: Radiographic Measurements



LSA DSA LHO

Table 1: Multivariable Regression: Factors Associated with Acromial Stress Fracture		
Covariate	Odds Ratio (95% CI)	P
Age$	1.60 (1.07, 2.39)†	**0.021**
BMI•	0.80 (0.62, 1.03)	0.084
Total Glenoid Lateral Offset @	1.57 (1.06, 2.31)†	**0.023**
Neck Shaft Angle•	0.74 (0.52, 1.05)	0.091
Spacer Thickness$	2.27 (0.24, 21.17)	0.472
Liner Thickness$	1.26 (1.00, 1.60)	0.054
Length of Follow-up$	1.12 (0.95, 1.31)	0.175
Female Sex (Reference: Male)	1.77 (1.23, 2.55)†	**0.002**
Current Smoker	1.17 (0.63, 2.18)	0.619
Presence of Osteoporosis	2.00 (1.36, 2.96)†	**<0.001**
Presence of Inflammatory Arthritis	2.19 (1.48, 3.23)†	**<0.001**
Revision Surgery (Reference: Primary Procedure)	0.38 (0.17, 0.84)†	**0.017**
Diagnois		
Cuff Tear Arthropathy (Reference: Other)	1.78 (1.25, 2.53)†	**0.002**
Massive Rotator Cuff Tear (Reference: Other)	2.09 (1.21, 3.61)†	
Presence of Os Acromiale	1.50 (0.76, 2.94)	0.242
History of Prior Ipsilateral Shoulder Surgery	1.84 (1.30, 2.59)†	**<0.001**
Non-Constrained Liner (Reference: Constrained Liner)	0.88 (0.56, 1.37)	0.574
Multivariable Regression: Radiographic Factors Associated with Stress Fracture		
Covariate		
Average Delta Distalization Shoulder Angle	0.94 (0.71, 1.23)	0.635
Average Delta Lateralization Shoulder Angle	1.42 (1.11, 1.81)†	**0.005**
Average Lateral Humeral Offset	0.74 (0.56, 0.97)†	**0.031**

† - Significant values; $ - Increasing value associated with greater OR
• - Increasing value associated with lower OR
CI - Confidence Interval
@ - OR reported as IQR-OR (10mm vs. 2mm) but tested as continuous variable. Glenoid lateral offset defined as sum of glenosphere, baseplate, and bone graft lateral offset