Effect of Degree of Posterosuperior Cuff Tear Severity on Joint Contact Patterns in Reverse Shoulder Arthroplasty

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INTRODUCTION: Reverse shoulder arthroplasty (RSA) has become a standard treatment for rotator cuff tear arthropathy in elderly individuals [1]. Despite the clinical success of RSA, massive rotator cuff tears can lead to the risk of joint subluxation or early loosening of the glenoid-side component [2]. Whereas preservation of the posterosuperior cuff has been proposed as a viable treatment option for patients undergoing RSA [3], it may not be possible due to the degradation of tendon quality or the preoperative amount of retraction [3, 4]. Posterosuperior cuff tears in RSA can disrupt the muscle force balance between the anterior (i.e., subscapularis) and posterior (i.e., infraspinatus and teres minor) cuff, thus resulting in reduced joint compression and changes in the magnitude and orientation of the glenohumeral joint contact force [5]. However, the manner by which posterosuperior cuff tears affect the joint compression and joint contact patterns in RSA is yet to be elucidated. Therefore, the aim of this study was to investigate the effect of the degree of posterosuperior cuff tear severity on the joint compressive force and center of pressure (COP) displacement in RSA.

METHODS: Ten male subjects participated in the experiments after signing an informed consent document approved by the Institutional Review Board. An experimental task was conducted for 6 seconds: 120° abduction in the coronal plane for 3 seconds, returning to the resting position for 3 seconds. The human *in vivo* experimental data was used as an input to the musculoskeletal model. The RSA model was developed by importing prosthetic bone geometries (Corentec, Coralis Reverse Shoulder System) into the musculoskeletal model. Inverse dynamic simulations of the musculoskeletal model of RSA were performed on the four posterosuperior cuff tear severity type models: Type A = isolated bundle tear of the supraspinatus; Type B = Type A + superior bundle tear of the infraspinatus; Type C = Type B + middle bundle tear of the infraspinatus; Type D = the entire bundle tear of the supraspinatus and infraspinatus. The intact rotator cuff model of RSA was also simulated for comparison with the four types of models. Post hoc paired t-tests were performed to compare the peak joint compressive force and root-mean-square (RMS) of the medial-lateral (ML), superior-inferior (SI), and anterior-posterior (AP) COP displacements between the intact rotator cuff and each type of model of RSA.

RESULTS: The peak joint compressive force in each posterosuperior cuff tear severity model was not significantly different by comparing it with the intact rotator cuff model of RSA. In the Type B, C, and D conditions, significant differences in the RMS-COP_{ML}, -COP_{SI}, and -COP_{AP} were observed compared to the intact rotator cuff condition ($P < 0.01$). In the Type A condition, significant differences in the RMS-COP_{ML} and -COP_{SI} were observed ($P < 0.001$); however, the RMS-COP_{AP} was not significantly different compared to the intact rotator cuff condition.

DISCUSSION: Our results show that the more posterosuperior cuff tears progressed in RSA, the more COP displacement in the ML, SI, and AP directions was observed. Thus, our results suggest that the COP displacement in RSA is considerably affected by the degree of posterosuperior cuff tear severity. In addition, these results indicate that preservation or repair of the posterosuperior cuff in RSA could restore joint contact patterns during abduction. The muscle force imbalance between the anterior and posterior cuff can lead to less centralization of the joint contact force orientation at the glenohumeral joint and loss of joint stability [6]. Therefore, this study suggests that preservation or repair of the posterosuperior cuff during RSA can improve glenohumeral joint stability when the subscapularis remains intact.

SIGNIFICANCE/CLINICAL RELEVANCE: When the subscapularis remains intact, preservation or repair of the posterosuperior cuff during RSA can improve glenohumeral joint stability by restoring muscle force balance between the anterior and posterior rotator cuff.

REFERENCES: [1] Boileau et al. (2006). *J. Shoulder Elb. Surg.*, 15, 527-540. [2] Edwards et al. (2009). *J. Shoulder Elb. Surg.*, 18, 892-896. [3] Nazzal et al. (2023). *J. Shoulder Elb. Surg.*, 32, S60-S68. [4] Sirveaux et al. (2010). *Orthop. Traumatol. Surg. Res.*, 96, 683-694. [5] Ackland et al. (2019). *J. Orthop. Res.*, 37, 211-219. [6] Khandare et al. (2022). *J. Electromyogr. Kinesiol.*, 62, 102335.

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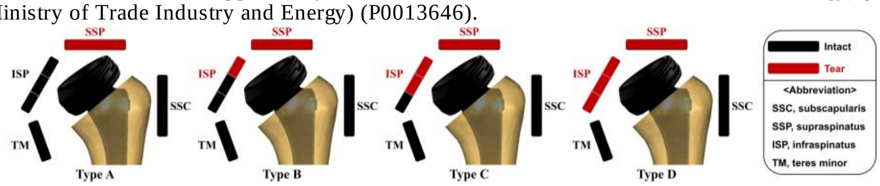

Figure 1 Rotator cuff configuration in the musculoskeletal model of RSA: Type A, isolated bundle tear of the supraspinatus; Type B, Type A + superior bundle tear of the infraspinatus; Type C, Type B + middle bundle tear of the infraspinatus; Type D, entire bundle tear of the supraspinatus and infraspinatus.

Table 1 Comparison of the root-mean-square of the center of pressure between the intact rotator cuff and each posterosuperior cuff tear severity model of RSA.

Type of models	RMS-COP_{ML}	RMS-COP_{SI}	RMS-COP_{AP}
Intact rotator cuff	6.211 ± 0.261	5.356 ± 0.930	1.346 ± 0.500
Type A	6.170 ± 0.262	5.415 ± 0.922	1.349 ± 0.495
P-value	*< .001*	*< .001*	*0.208*
Type B	6.163 ± 0.258	5.417 ± 0.937	1.375 ± 0.491
P-value	*< .001*	*< .001*	*0.002*
Type C	6.147 ± 0.254	5.439 ± 0.951	1.404 ± 0.498
P-value	*< .001*	*< .001*	*0.002*
Type D	6.104 ± 0.259	5.489 ± 0.979	1.449 ± 0.532
P-value	*< .001*	*< .001*	*0.001*

Data are presented as mean displacement (mm) ± standard deviation.

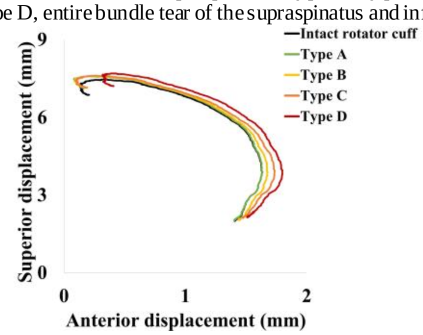

Figure 2 Displacement of the COP of the humeral head on the glenoid.