Effect of combined component version on impingement-free rotational range of motion in three different implant types in reverse shoulder arthroplasty

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INTRODUCTION: Bony impingement following reverse shoulder arthroplasty (RSA) has been implicated in glenoid component loosening and poor functional outcomes over time and has been shown to develop from impingement along the scapular neck. Studies have investigated the effects of implant design, glenosphere position/offset, and glenoid or humeral component version on impingement-free range of motion (ROM), however, the influence of combined humeral and glenoid component version has not previously been evaluated. The purpose of this study was to determine the effects of varying combinations of humeral and glenoid component version on impingement-free ROM in three different RSA designs. We hypothesized that increased combined retroversion would decrease impingement-free ROM, regardless of implant type.

METHODS:

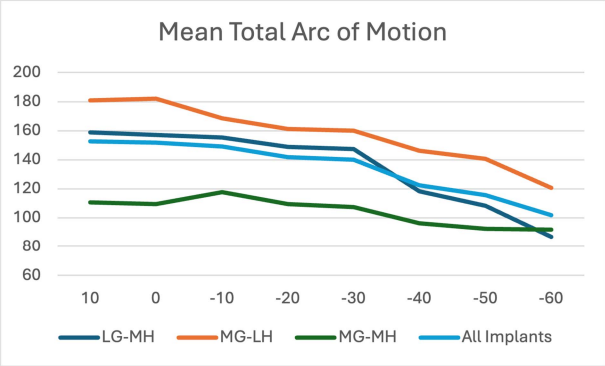
Nine patients with posterior glenoid bone loss (2 B2, 7 B3 glenoids) indicated for RSA underwent preoperative shoulder CT with inclusion of the entire scapula and humerus. CT images were reconstructed in a custom three-dimensional imaging software that allowed for virtual templating of RSA components and subsequent simulation of glenohumeral ROM. Virtual templating was performed on each patient using three different RSA designs: a medial glenoid-medial humerus (MG-MH) design having a 38 mm, +0 mm offset glenosphere and inlay humeral component with 155º neck-shaft angle, a medial glenoid-lateral humerus (MG-LH) design having a 38 mm, +3 mm offset glenosphere and onlay humeral component with 145º neck-shaft angle, and a lateral glenoid-medial humerus (LG-MH) design having a 32 mm, +10 mm offset glenosphere and inlay humeral component with 135º neck-shaft angle. The baseplate was positioned at the inferior border of the glenoid and in the center of the glenoid vault at 0º inclination, with 50% bone contact in all cases. Each implant was then placed in different combinations of glenoid component version (10º, 0º, -10º, -20º, while maintaining the other parameters of baseplate position) and humeral component version (0º, -10º, -20º, -30º, -40º) for virtual simulations. Virtual glenohumeral ROM was performed at 0º, 30º, and 90º abduction in the scapular plane, measuring internal rotation (IR) and external rotation (ER) at each level of abduction. Primary outcome measures were total impingement-free ROM (combined IR and ER), impingement-free ER ROM, and impingement-free IR ROM, assessed at each level of abduction for each implant design at each combined component version. A scapular contact mesh was created to determine impingement locations for all simulations. A linear mixed effects model was applied to assess the association between implant type and impingement-free ROM (total, ER, IR), adjusting for glenoid and humeral version.

RESULTS:

Mean preoperative CT glenoid measures were: -18.8º version, 4.3º inclination, 4.7mm joint line medialization, and 6.2mm maximum bone loss. Total impingement-free ROM was decreased for each patient as combined component retroversion increased, particularly with combined retroversion beyond 30º. Impingement-free ER ROM increased with more combined component retroversion until 30º, while the contrary was found for impingement-free IR ROM. The greatest total arc of impingement-free ROM was found at 30º abduction for all patients at all combined versions. In the linear mixed effects model, implant type, glenoid version and humeral version were significantly associated with total impingement-free ROM (Table 1). Compared to the LG-MH design, the MG-LH design was associated with increased ROM (26.3°) and the MG-MH design with decreased ROM (-36.6°) (Figure 1). Compared to glenoid component version of 0°, +10° version was associated with increased ROM (20.7°) and both -10° and -20° version with decreased ROM (-10.1° and -23.0°, respectively). Humeral component version was associated with decreased ROM (-18.3°) only at -40° version. In looking at impingement-free IR and ER ROM, glenoid version changes were significantly associated only with IR ROM, while humeral version changes significantly impacted both IR and ER ROM (Table 1). The most common locations of bony impingement overall were the scapular neck and anterior/posterior glenoid at 0º abduction; anterior/posterior glenoid at 30º abduction; and superior glenoid, coracoid and acromion at 90º abduction. For each RSA design, the most common impingement was at the glenoid or scapular neck at 0º abduction for the MG-MH design; at the acromion or coracoid at 90º abduction for the MG-LH design; and at the superior glenoid or coracoid at 90º abduction for the LG-MH design.

DISCUSSION AND CONCLUSION: This study demonstrates that total impingement-free ROM in RSA decreases with combined component version below -30º. This suggests that when glenoid retroversion that cannot be corrected surgically, which may occur in the setting of advanced posterior glenoid bone loss, humeral component version should be decreased to avoid bony impingement. Total impingement-free ROM was greatest with the MG-LH design, and impingement location changed by implant design, with less scapular neck impingement in the MG-LH and LG-MH designs. The study is limited by not accounting for scapulothoracic motion or soft tissue considerations. Further

investigation is needed to determine how varying glenosphere size and degree of lateral offset impacts total impingement-free ROM and location of bony impingement.



	Total ROM		*ER*		*IR*	
	ΔROM° [95%CI]	P-value	ΔROM° [95%CI]	P-value	ΔROM° [95%CI]	P-value
MG-LH v LG-MH	26.3 (18.2 – 34.5)	<0.001	-1.9 (-6.7 – 2.9)	0.428	28.2 (22.0 – 34.5)	<0.001
MG-MH v LG-MH	-36.6 (-44.7 – -28.4)	<0.001	-34.8 (-39.6 – -30.0)	<0.001	-1.7 (-8.0 – 4.5)	0.587
Glenoid (-10 °v 0°)	-10.1 (-19.5 – -0.7)	0.035	2.5 (-3.0 – 8.0)	0.379	-12.6 (-19.8 – -5.3)	0.001
Glenoid (-20 °v 0°)	-23.0 (-32.4 – -13.6)	<0.001	4.7 (-0.9 – 10.2)	0.097	-27.7 (-34.9 – -20.4)	<0.001
Glenoid (10 °v 0°)	20.7 (11.3 – 30.1)	<0.001	-4.5 (-10.1 – 1.0)	0.107	25.2 (18.0 – 32.5)	<0.001
Humeral (-10 °v 0°)	0.1 (-10.4 – 10.6)	0.986	7.7 (1.5 – 13.9)	0.015	-7.6 (-15.7 – 0.5)	0.066
Humeral (-20 °v 0°)	-2.5 (-13.0 – 8.0)	0.642	12.5 (6.3 – 18.6)	<0.001	-14.9 (-23.0 – -6.9)	<0.001
Humeral (-30 °v 0°)	-8.0 (-18.5 – 2.4)	0.131	17.7 (11.6 – 23.8)	<0.001	-25.8 (-33.8 – -17.7)	<0.001
Humeral (-40 °v 0°)	-18.3 (-28.8 – -7.9)	0.001	17.2 (11.0 – 23.3)	<0.001	-35.5 (-43.6 – -27.5)	<0.001

Table 1. Linear mixed model regression results showing association of implant type, glenoid component version, and humeral component version with impingement-free total motion (ROM), external rotation (ER), and internal rotation (IR).