Scapulohumeral rhythm correlates with humeral distalization change after reverse total shoulder arthroplasty

Itaru Kawashima, Norimasa Takahashi, Keisuke Matsuki, Ryo Haraguchi, Hayato Ryoki, Scott A Banks, Thomas W Wright

INTRODUCTION:

Scapulohumeral rhythm (SHR) in shoulders following reverse total shoulder arthroplasty (rTSA) is typically reduced, with motion relying heavily on scapulothoracic movement during elevation or abduction.[1] Previous studies have reported that higher SHR after rTSA is associated with improved shoulder elevation and better patient-reported outcome measures (PROMs).[2,3] Therefore, despite its non-anatomic design, it is preferable to achieve better SHR following rTSA. Although implant positioning is believed to influence postoperative kinematics, including SHR, the specific factors contributing to better SHR remain unclear.

The aim of this study was to investigate the relationship between postoperative SHR and humeral lateralization or distalization, as well as medialization or distalization of the center of rotation (COR).

METHODS:

This study was approved by the Institutional Review Board and Ethics Committee of our institution. Forty-six shoulders from 45 patients who underwent surgery at a single institution and achieved over 90 degrees of humeral abduction were enrolled. The cohort consisted of 27 men and 18 women, with a mean age of 75 years (range, 46–85 years).

The surgical procedures included 15 shoulders treated with inlay rTSA with a medialized glenoid and medialized humerus (MGMH) configuration (Aequalis Reverse, Stryker, MI, USA), 13 shoulders treated with onlay rTSA with a medialized glenoid and lateralized humerus (MGLH+) (Equinoxe, Exactech, Gainesville, FL, USA), and 19 shoulders treated with semi-inlay rTSA with a medialized glenoid and mildly lateralized humerus (MGLH) (Medacta Shoulder System 145°, Medacta International, Castel San Pietro, Switzerland).[4]

At a mean of 14 months postoperatively (range, 12–27 months), computed tomography (CT) and fluoroscopy were performed. Fluoroscopic images were acquired during unassisted active scapular plane abduction from arm at side to maximal elevation over approximately 5 seconds.

Three-dimensional (3D) models of humeral implants provided by manufacturers and scapular implants reconstructed from CT were used for analysis. Anatomic coordinate systems were embedded, and the poses of the 3D models were iteratively adjusted to align with the silhouettes in the fluoroscopic images using model-image registration techniques (Figure 1). SHR was defined as $(\Delta H - \Delta S)/\Delta S$, where ΔH is the increment in humeral elevation angle and ΔS is the increment in scapular upward rotation angle.[1] SHR was calculated at each 10° increment from 20° to 90° of humeral abduction. The mean postoperative SHR was assessed from 20 to 90° of humeral abduction.[3]

Implant positioning parameters were measured from postoperative Grashey view radiographs within 3 months of surgery. The COR was defined as the center of a best-fit circle on the glenosphere. Humeral distalization was measured as the distance from the lateral acromial undersurface to the greater tuberosity tip; distalization of the COR as the distance from the acromial undersurface to the COR; humeral lateralization offset as the distance from the lateral acromion edge to the greater tuberosity tip; and medialization of the COR as the distance from the COR to the lateral acromion edge (Figure 2). Preoperative measurements were obtained similarly. Change values were calculated as Δpost – pre for each metric (e.g., Δhumeral distalization = postoperative – preoperative).

Pearson's correlation coefficient evaluated relationships between mean SHR (20°–90° abduction) and each parameter, with $p < 0.05$ considered significant.

RESULTS:

The mean SHR from 20° to 90° of humeral abduction was 1.39 ± 0.64. A significant positive correlation was observed between the mean SHR and Δhumeral distalization (r = 0.321, P = 0.030) (Table 1). There was no significant correlation between the mean SHR and other parameters.

DISCUSSION AND CONCLUSION:

This study demonstrated a significant positive correlation between postoperative SHR and the change in humeral distalization from preoperative to postoperative values. This finding suggests that increased deltoid tension resulting from distalization may contribute to improved SHR, as elongation of the deltoid muscle through humeral distalization has been shown to enhance shoulder elevation torque.[5]

Humeral-sided lateralization combined with medialization of COR has been reported to improve deltoid efficiency,[6] which may also influence SHR. However, global humeral lateralization may overstrain muscles such as the teres minor, increasing adduction forces,[7,8] and potentially negating its beneficial effects on SHR.

In conclusion, increasing humeral distalization from preoperative to postoperative may play a key role in improving SHR following rTSA.

References

1. Walker D, et al. J Shoulder Elbow Surg. 2015.
2. Friesenbichler B, et al. Arch Orthop Trauma Surg. 2021.
3. Kawashima I, et al. J Shoulder Elbow Surg. 2025.
4. Werthel JD, et al. Int Orthop. 2019.
5. De Wilde L, et al. Clin Biomech (Bristol). 2002.
6. Giles JW, et al. Clin Orthop Relat Res. 2015.
7. Franceschetti E, et al. Int Orthop. 2019.
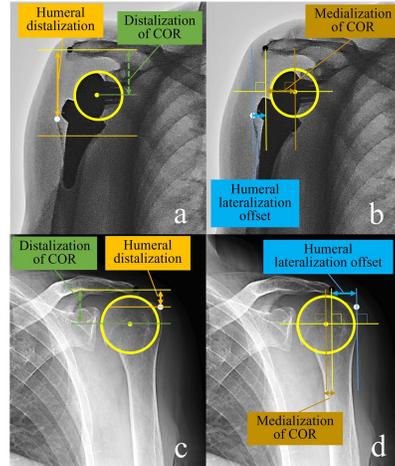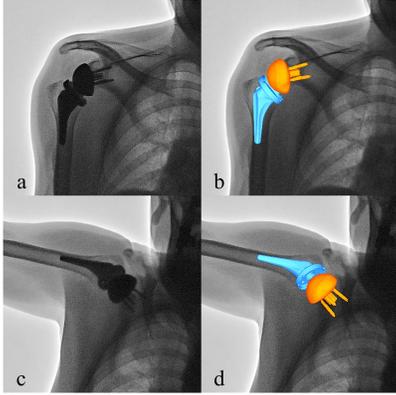8. Herrmann S, et al. J Orthop Surg Res. 2011.

TABLE 1: Correlation coefficient between the mean SHR and each parameter

	Mean value, mm	Correlation coefficient	P value
Postoperative values			
Humeral lateral offset	7.0 ± 8.4	-0.073	0.630
Medialization of the COR	31.9 ± 6.1	0.002	0.989
Humeral distalization	44.0 ± 6.3	0.201	0.180
Distalization of the COR	32.9 ± 5.3	0.118	0.434
Δ = (postoperative values − preoperative values)			
ΔHumeral lateral offset	-6.0 ± 8.7	-0.028	0.853
ΔMedialization of the COR	20.7 ± 6.4	-0.045	0.767
ΔHumeral distalization	26.3 ± 7.3	0.321	**0.030**
ΔDistalization of the COR	4.9 ± 6.0	0.120	0.427

The values are given as mean ± standard deviation (range).
Bold text indicates a significant P value.
COR, center of rotation