

# Correction of Humeral Head Alignment and Glenoid Component Placement Precision in Anatomic Total Shoulder Arthroplasty

Nazanin Daneshvarhashjin<sup>1</sup>, Philippe Debeer<sup>2</sup>, Filip Verhaegen<sup>2</sup>, Lennart Scheys<sup>1,2</sup>

<sup>1</sup>KU Leuven University, Leuven, BE, <sup>2</sup>UZ Leuven Hospital, Leuven, BE

Email: nazanin.daneshvarhashjin@kuleuven.be

**Disclosures:** Nazanin Daneshvarhashjin, Philippe Debeer, Filip Verhaegen, and Lennart Scheys (Zimmer Biomet company)

**INTRODUCTION:** Anatomic total shoulder arthroplasty (aTSA) relieves pain and improves function of patients with end-stage shoulder osteoarthritis (OA). As glenohumeral bony deformity and posterior humeral head migration (HHM) typify most OA cases, correcting these bony deformities in terms of version and inclination; and aligning the humeral head (HH) center is a generally-accepted surgical goal. Nevertheless, precise glenoid deformity correction in aTSA still poses challenges, even with computer-aided preoperative planning, and its effect on HH alignment is poorly understood. Therefore, this research aims to assess: (1) the accuracy of surgical corrections in comparison to the defined pre-operative plan and (2) the effect of these intraoperative deformity corrections on the HH alignment post-operatively.

**METHODS:** The local ethical committee approved this prospective study. 22 OA patients (11 A glenoids, 11 B glenoids) scheduled for primary aTSA using the Comprehensive Total Shoulder System (Zimmer-Biomet®) combined with patient-specific surgical guides were included. 3D bone shapes were segmented with Mimics (Materialise, Belgium) from standard-of-care pre- and post-CT scan data (Fig1 A and B). Scapular and transverse planes were defined using 3D landmarks in the pre-op CT data. A sphere was fitted to the HH and its corresponding center as well as the glenoid center were defined (Fig1 C). The 3D STL file of the glenoid component corresponding to the implanted one was chosen and manually registered to the post-op CT scan (Fig1 B). The best-fitting plane to the glenoid component surface and its corresponding center, as well as the implanted HH center, were identified. The post-op scapula was then registered to the pre-op model using 3-matic (Materialise NV) to transfer the pre-op reference planes to the post-op scans (Fig1 D). Anterior-posterior (AP) HH center offset was measured as the deviation of the distance between the HH center or implanted HH and the glenoid or glenoid component center from the scapular plane. The superior-inferior (SI) offset of the HH center was measured similarly considering the transverse plane as the reference plane. The values of pre- and post-op HHM were then calculated by normalizing the obtained offsets based on the patient-specific HH diameter. Glenoid version and inclination were measured both pre- and post-op using the defined reference planes. Differences between planned and intraoperative corrections were measured. All measurements were performed semi-automatically using custom scripts in 3-matic. Additionally, the glenoid center translation (GCT) was measured as the distance between the preoperative glenoid center and glenoid component center in SI and AP directions. A stepwise linear regression model was used to identify which of the above-analyzed parameters significantly predicted the postoperative HH alignment. All statistical analyses were performed using SPSS.

**RESULTS:** The pre- and post-op anatomical measurements are summarized in Table 1. The surgical error for correction of version for all patients was  $0.1^\circ \pm 5.5$  ( $-2.6^\circ \pm 5.9$  for A glenoid and  $2.5^\circ \pm 4.0$  for B glenoid). The error for inclination correction was  $-9.3^\circ \pm 5.4$  ( $-8.4^\circ \pm 3.2$  for A glenoid and  $-10.1^\circ \pm 6.9$  for B glenoid). Multiple regression analysis showed that the postoperative version was a significant predictor of the magnitude of the postoperative HHM-AP ( $R=0.71$ ,  $p<0.05$ ). However, inclination had no statistically significant correlations with HHM-SI postoperatively.

**DISCUSSION:** Based on our preliminary results the precision of inclination correction is less than version correction, resulting in more inferior inclination. Interestingly, the postoperative glenoid component version was highly predictive of HHM AP postoperatively. However, we did not find any correlations between inclination and HHM SI postoperatively. In interpreting HHM SI, we should notice that although inaccuracy in correcting inclination (i.e. amount of inclination correction) had no effect on HHM SI, we did observe an inferior translation of the glenoid component. This means the loading center will move to the inferior part of the glenoid in comparison to the pre-op, which may lead to glenoid loosening. Continued enrollment of patients in our study will contribute to a more definitive conclusion.

**SIGNIFICANCE/CLINICAL RELEVANCE:** The results could refine surgical techniques and pre-operative planning, enhance patient outcomes, and contribute to the understanding of factors influencing shoulder arthroplasty success.

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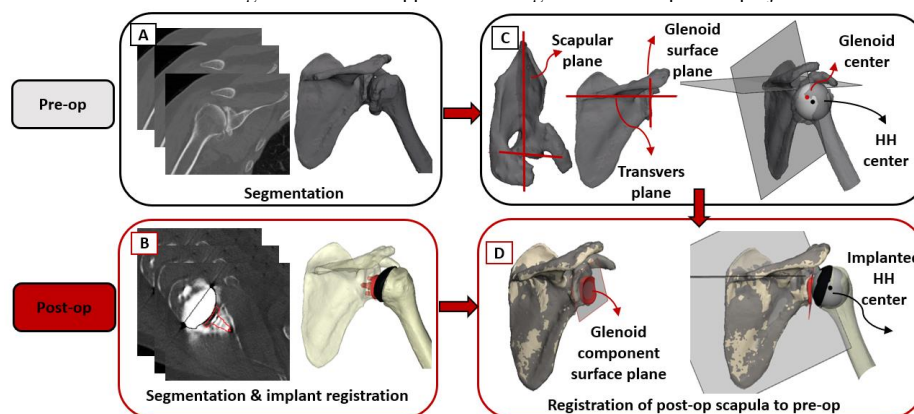


Figure 1 Overview of the study methodology

Table1. 3D anatomical measurements based on pre-and post-op CT scans.

Group	Pre-op-CT				Post-op-CT				Glenoid center translation	
	Retro-version (°)	Inclination (°)	HHM AP (%)	HHM SI (%)	Retro-Version (°)	Inclination (°)	HHM AP (%)	HHM SI (%)	Anterior GCT (mm)	Inferior GCT (mm)
OA	6.3±8.9	-1.9±4.8	59.4±9.1	51.8±5.9	0.74±6.9	-8.6±6.6	54.6±6.4	48.8±7.2	0.15 ± 1.6	2.0 ±3.06
A glenoid	0.3±4.6	-0.8±4.5	51.8±4.7	54.1±4.9	-2.2±5.3	-5.9±5.8	51.9±4.7	51.6±5.8	0.4. ± 2.0.	1.12 ±2.0
B glenoid	12.3±8.1	-3.0±5.0	67.0±4.8	49.5±6.1	3.7±7.3	-11.3±6.5	57.2±7.0	46.0±7.7	0.1 ±1.13	2.9±3.8