QUANTIFYING HUMERAL HEAD MIGRATION IN SHOULDER OSTEOARTHRITIS USING BIPLANAR RADIOGRAPHY

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Introduction

Shoulder osteoarthritis (OA) is known to be associated with a wide range of bone erosion patterns and variable Humeral Head Migration (HHM) in the glenoid joint surface. This variability is known to importantly affects glenohumeral function and kinematics. The magnitude and direction of HHM based on static CT scan images are one the key assessments in surgical planning of anatomic Total Shoulder Arthroplasty (aTSA). However, these assessments in multiple functional arm positions could provide more functionally-relevant information for surgical planning. Therefore, the purposes of this study are (1) to assess the reliability of a methodology for measuring 3D in-vivo HHM in different quasi-static functional arm positions based on biplanar radiographs and (2) to assess the variability among patients with shoulder OA in this regard.

Method

Low-dose bi-planar radiographs (EOS imaging, Paris, France) were collected in 10 patients with shoulder OA, planned for an aTSA. Each patient was scanned at 8 different quasi-static arm positions: relaxed standing (RS), extension (EX-45º), flexion (F-45º, F-90º and F-120º), and abduction (AB-45º, AB-90º and AB-120º). The 2D scapula and humerus contours were segmented from the frontal and lateral images of the EOS images. Smoothed 3D bone shapes were manually segmented with Mimics (Materialise, Belgium) from standard-of-care CT scans. Custom MATLAB code was used to register the 3D bone shapes to the respective bi-planar contours and quantify the humeral head position with respect to the glenoid (Fig. 1) [1]. Hereto, a sphere was automatically fitted to the humeral head and its corresponding center was determined. Similarly, the glenoid center was defined based on a best-fitted plane. Next, the HHM, evaluated as the translation of the humeral head center relative to the glenoid center, was measured in superior-inferior (SI) and anterior-posterior (AP) direction for all patients and positions and normalized to the humeral head diameter (Fig.1) [2]. Inter- and intra-observer reproducibility of the reconstructions were assessed by measuring surface-to-surface error (STSE) of the humerus and scapula and through intra-class correlation coefficients (ICCs).

Results

The ICC of posterior HHM in RS, AB-45, and F-45 showed good inter- and intra-rater reliability ranging from 0.8 to 0.9 ($p<0.05$). The STSE for the scapula and humerus in these three positions is reported in Table 1. The other positions demonstrated only moderate or poor (120AB) reliability (ICC<0.8 and P>0.05). The humerus center was located inferior-posteriorly in OA patients for CT, RS, 45F, and 45AB (Fig.2). Although paired t-test showed no significant differences between RS compared to CT-scan-based measurements ($p>0.05$), a trend towards more inferior-posterior HHM was observed in the upright RS compared to supine posture in the CT-scan (51.6±7.3 vs. 53.8±7.8% for SI and 58.2±8.9 vs. 57.0±8.1% for AP, respectively). 45AB and 45F were both associated with greater posterior HHM (63.21±13.7 and 62.74±.9.9% of A-P HHM).

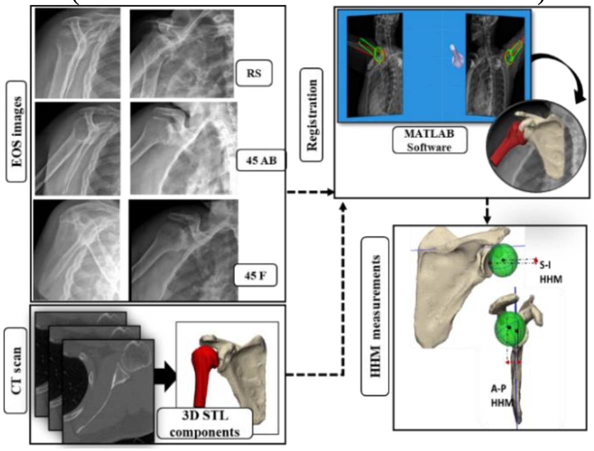

Figure 1: Process of reconstructing the joint positioning

Component	STSE (mm)	
	Intra-rater median (IQR)	Inter-rater median (IQR)
Scapula	4.7 (4.4)	6.6 (6.5)
Humerus	9.1 (4.0)	5.5 (3.4)

Table 1: STSE of the components in RS, 45AB and 45F

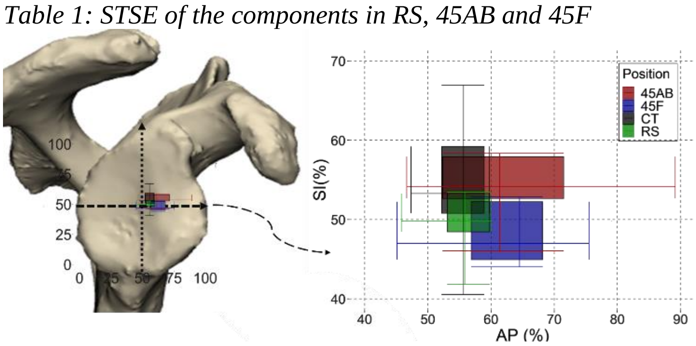

Figure 2: Humerus center location in the glenoid plane

Discussion

The current methodology was shown to be reliable for three functional arm positions. Variability among patients in terms of posterior HHM in these positions has the potential for pre-operative clinical evaluation.

References

1. Dejtiar DL et al. J Biomech Eng, 86: 34-9, 2019.
2. Jacxsens M et al. J Shoulder Elb Surg, 24:541–546, 2015.