

The Glenoid Track Varies in Size and Location with Abduction Angle and Load

Clarissa LeVasseur¹, Zhaoyi Fang², Devon Scott¹, Jill Brockhoff¹, Jonathan Hughes¹, Albert Lin¹, William Anderst¹

¹Biodynamics Laboratory, University of Pittsburgh, Pittsburgh, PA

Email of Presenting Author: c11100@pitt.edu

Disclosures: LeVasseur (N), Fang (N), Scott (N), Hughes (N), Lin (3B: Stryker, Arthrex), Anderst (5: Smith&Nephew),

INTRODUCTION: Anterior shoulder instability accounts for approximately 80% of all shoulder instability [1,2], and occurs at a rate of 3% per year in specific at-risk young athletes and military personnel [2,3]. Rates are even higher in collision athletes [4]. Simultaneous defects of the humeral head and glenoid are well known pathoanatomical changes associated with anterior instability [5], therefore, understanding the dynamic articulation between the humeral head and glenoid is vital to properly identify patients at risk for recurrence and to make informed decisions regarding the optimal surgical procedure for the patient. Current treatment guidelines for patients with anterior instability are based upon the glenoid track concept, which was developed from biomechanical studies that measured glenohumeral (GH) articular contact patterns during simulated loading in cadavers [6] and static imaging of healthy individuals [7]. Previous work has reported that the static glenoid track width in maximum external rotation (ER) changes with abduction, but no work has been done to quantify the glenoid track dynamically with varying levels of abduction, nor to evaluate the effect of an additional load on the glenoid track. The aim of this ongoing study is to characterize the effects of GH abduction, GH ER, and load on the glenoid track area and location.

METHODS: Healthy, asymptomatic individuals with no history of shoulder pathology provided written informed consent prior to participating in this IRB-approved study. Participants received bilateral CT (resolution: 0.44x0.44x0.625mm) and bilateral MRI scans (DESS sequence, resolution: 0.3x0.3x0.3mm). Participants performed 2 trials with each arm of continuous internal/external rotation to the beat of a metronome set at 63 beats per minute in four different humerothoracic abduction angles (approximately 30°, 60°, 90°, and 120°) while synchronized biplane radiographs of the shoulder were collected at 50 images/s for 1.5 seconds (90 kV, 50mA, 2ms pulse width) to capture ER. One of the two trials on each side in each abduction angle was performed with the participant holding a 5lb weight in the hand of the side that was being imaged. Digitally reconstructed radiographs, created from subject-specific segmented bone tissue of the humerus and scapula, were matched to the biplane radiographs with sub-millimeter accuracy [8] to determine six degree-of-freedom scapular and glenohumeral kinematics. Bone and cartilage were segmented from the MRIs and co-registered to the CT-based bone models. The glenoid to humeral cartilage overlap was determined for every frame of data. The cartilage overlap boundary was expressed in spherical coordinates. Data from all four corresponding trials (same side, weight condition, varying abduction levels) were then interpolated to 5° increments of GH abduction and ER to estimate the dynamic glenoid track at every 5° increment of abduction and ER. The glenoid track areas were normalized among subjects using the boundary of the humeral cartilage for each shoulder. Both the area and the center of the glenoid track (in spherical coordinates, with azimuth roughly describing the anterior/posterior position, and elevation describing the superior/inferior position) were evaluated in 10° increments of GH abduction between 40° and 70° and in 5° increments of ER between 5° and 50°. Absolute side-to-side differences in the location and area of the glenoid track were determined at corresponding angles of abduction and ER. Averages and standard deviations were used to characterize changes in glenoid track location and area as a function of abduction and ER during weighted and unweighted conditions.

RESULTS: Data processing is complete for 6 of the 30 participants who completed the study (6M, 34.3±11.2yrs., BMI: 26.6±4.2kg/m²), resulting in 96 movement trials included in the analysis. The center of glenoid track on the humerus moved in the superior-posterior direction during ER. Each 10° increase in GH abduction resulted in the glenoid track location being 3.2±1.3mm more superior and 1.3±2.4mm more posterior for any given amount of ER, while decreasing the contact area by 31.3±60.2mm² (Figure 1). Adding the 5lb weight moved the average glenoid track location 0.5±1.0mm more superior and 1.7±3.0mm more posterior for any given amount of ER while increasing the contact area by 16.7±94.0mm² (Figure 1). The contact area decreased with ER in all conditions (Figure 1B). The average absolute side-to-side differences in glenoid track location were 5.7±3.1mm in the anterior/posterior direction and 3.6±1.5mm in the superior/inferior direction, while the average absolute side-to-side difference in glenoid track area was 151.0±88.1mm² at corresponding abduction and ER angles.

DISCUSSION: The main findings of this interim analysis were that the glenoid track moves posteriorly and superiorly with increasing abduction while decreasing in area with ER. Adding load leads to a more posterior and superior, and slightly larger, glenoid track. These findings corroborate previous literature that reported the glenoid track moves superior with increasing abduction angles. Side-to-side differences in glenoid track area and location are large in this small cohort, suggesting that a patient's contralateral side may not be a good reference for comparison when evaluating the effects of injury, surgery, and rehabilitation on the dynamic glenoid track. These interim results are limited to a small cohort of healthy men performing controlled, active external rotation. Future work will explore the effects of sex, bony morphology, and anterior shoulder instability on the dynamic glenoid track.

CLINICAL RELEVANCE: Sport-specific movement and loading requirements may need to be considered when evaluating the risk of future dislocation in anterior shoulder instability patients.

REFERENCES: [1] Dodson et al. *Orthop Clin North Am.* 2008. [2] Owens et al. *AJSM.* 2007. [3] Waterman et al. *Sports Health.* 2016. [4] Kawasaki et al. *JSES.* 2014. [5] Lemme et al. *JBJS Rev.* 2019. [6] Yamamoto et al. *JSES.* 2007. [7] Omori et al. *AJSM.* 2014. [8] Bey et al. *J Biomech.* 2006.

ACKNOWLEDGEMENTS: This work was funded by NIH Grant: R01-AR080425.

