Prosthesis Design and Surgical Technique Impact *In-Vivo* Contact Patterns after Reverse Shoulder Arthroplasty during Abduction

Gillian E Kane, Clarissa Levasseur[1], Ajinkya Rai, Maria A. Munsch, Alexandra S Gabrielli, Jonathan D Hughes[2], William Anderst[1], Albert Lin[3]
[1]University of Pittsburgh, [2]UPMC Freddie Fu Sports Medicine Center, [3]Freddie Fu UPMC Sports Medicine Center

INTRODUCTION:

Reverse shoulder arthroplasty (RSA) reduces pain and dysfunction in patients with rotator cuff arthropathy[1]. The aim of this study was to determine the effects of surgical technique and implant geometry on *in vivo* kinematics and strength during abduction after RSA. We hypothesized that 1) a smaller humeral neck shaft angle would be associated with increased GH abduction, 2) increased humeral retroversion would be associated with a more posterior contact path on the glenosphere, and 3) greater lateralization would be associated with a greater scapulohumeral rhythm (SHR), and more strength.

METHODS:

Thirty-five patients received RSA (17M, 18F, 72.8±7.3years) using a standard 145° onlay humeral implant (145°OHI) or a 135° inlay humeral implant (135°IHI). Synchronized biplane radiographs were collected during 3 abduction trials 2.2±1.1 years after receiving RSA. Scapular and GH kinematics were determined using a validated technique that matched 3D models to radiographs with sub-millimeter accuracy (Figure 1A-F)[2]. The center of contact between a 3D CAD model of the polyethylene and the glenosphere was calculated and the superior/inferior (SI) and anterior/posterior (AP) locations were averaged across corresponding GH abduction angles. GH abduction and scapular upward rotation were averaged across trials at corresponding humerothoracic rotations and used to calculate the average scapulohumeral rhythm (SHR). Glenoid tilt and humeral retroversion were calculated from 3D models from CT-scans. Lateralization, neck-shaft angle, glenosphere size, and eccentricity were recorded from surgical notes. A machine set to 30° per second was used to measure isokinetic torque throughout full ROM abduction and adduction. Peak torque and total work done for both abduction and adduction were found from the torque/angle curves and normalized to bodyweight. Implant characteristics and surgical techniques that were associated with kinematics were identified using multiple linear regression using forward selection. Associations between kinematics and strength were evaluated with a pearsons correlation. Significance was set at $p<0.05$ for all tests.

RESULTS:

Greater neck shaft angles, and retroversion angles were associated with a more anterior contact path between the humeral implant and glenosphere (Figure 2A-B, $R=0.778$, $p<0.001$). The ability to perform more work during abduction was associated with greater maximum GH abduction ($p=0.006$), increased glenosphere size ($p=0.008$), and higher peak superior contact points ($p<0.001$). The ability to produce greater peak torque during abduction was associated with increased glenosphere size ($p<0.001$), greater retroversion angles ($p=0.014$), and a more superior contact path ($p=0.034$). Greater neck shaft angle was associated with greater abduction ROM ($p=0.037$). No other associations between implant characteristics or surgical techniques and strength, kinematic parameters, or ROM were found. Average SHR was 0.9±0.3°. Contrary to our hypothesis, no associations between implant characteristics or surgical techniques and SHR were found (all $p>0.05$).

DISCUSSION AND CONCLUSION:

This study identified greater neck shaft angle and retroversion angles as implant parameters and/or surgical techniques that are associated with *in-vivo* changes in contact path during abduction after RSA. Changes in contact path location are important to consider as they may impact polyethylene wear patterns. Despite knowing that volumetric wear of the polyethylene is high in RSA, there has been little information about the abrasive wear caused by the sliding of the articular surfaces of reverse implants that could be affected by contact path location[4]. Additionally, the finding that subjects with greater glenosphere size and retroversion angle were able to generate more torque further supports prior studies that found increased deltoid load with larger glenosphere size though this may not impact PROs[3]. Contrary to our hypothesis and previous cadaveric studies[5], we were unable to find any *in vivo* evidence that lateralization impacts strength. These findings highlight the importance of having *in-vivo* data to confirm cadaver-based research and computer simulations that do not account for healing and changes in neuromuscular control after surgery. An improved understanding of how implant design and surgical technique impact kinematics and functional outcomes is necessary to ensure optimal function after RSA. Results are limited as only one planar motion was analyzed.

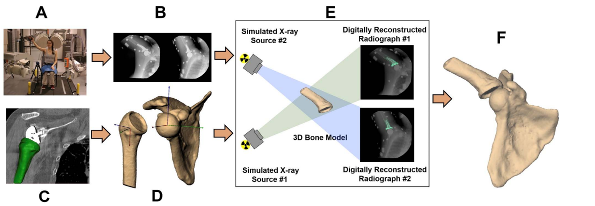

Figure 1. Data Work Flow(A) *Participants performed abduction in the scapular plane with their affected shoulder while* ***(B)****synchronized biplane radiographs were collected.* ***(C)****CT scans of the affected shoulder were collected and* ***(D)****used to create 3D bone models with anatomical coordinate systems.* ***(E)****3D glenohumeral positions were determined using a validated CT model-based tracking process.* ***(F)****6 DOF kinematics were calculated.*

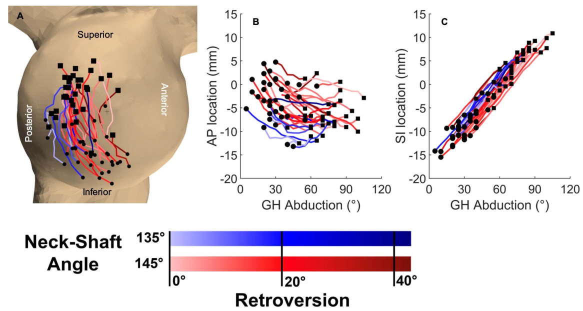

Figure 2. Contact Center During Abduction. *Blue lines represent participants with 135°IHI while red lines represent participants with 145°OHI. Circles indicate the start of abduction and boxes indicate maximum abduction. Darker colors indicate more retroversion and lighter colors indicate less retroversion.* ***(A)*** *The path from lower abduction angles (circles) to maximum abduction angles mapped onto the glenosphere for each participant.* ***(B)*** *The change in AP location of the contact center with increasing abduction.* ***(C)*** *The change in SI location of the contact center with increasing abduction.*