Humeral distalization in reverse shoulder arthroplasty: a biorobotic shoulder simulator study

Christopher Joyce[1], Jared Louis Zitnay[2], madelyn stout, Brittany Percin, Robert Zaray Tashjian[2], Peter Nissen Chalmers[2], Gilles Walch, Heath Henninger[2]
[1]University of Utah, Department of Orthopaedics, [2]University of Utah

INTRODUCTION: Humeral distalization is inherent to reverse total shoulder arthroplasty (rTSA) and is often produced with concomitant humeral lateralization via the level of the humeral head cut, implant positioning, implant neck shaft angle, and polymer insert thickness. Biomechanical data on the isolated effects of humeral distalization remain limited, but could be important to consider when optimizing post-operative rTSA shoulder function. This study investigated the effects of isolated humeral distalization on shoulder biomechanics using a biorobotic shoulder simulator.

METHODS: Eight fresh-frozen cadaveric shoulders were tested using custom polymer inserts that translated the bearing surface 0, +5, +10, and +15 mm along the humeral stem axis, producing isolated distalization without lateralization. Specimens underwent passive elevation in the scapular plane with a static scapula to assess glenohumeral range of motion. Scapular plane abduction motion trajectories were performed, driven by previously collected scapulothoracic and glenohumeral kinematics from rTSA patients. The effect of isolated distalization on passive elevation was tested using mixed-effects linear regression and the effect on muscle force, joint reaction force, and muscle excursion during scapular-plane abduction was tested using statistical parametric mapping random effects analysis.

RESULTS: Maximum passive scapular plane elevation increased with humeral distalization (4° per 5 mm distalization). Deltoid and rotator cuff muscle forces, and joint reaction forces, increased up to 37% per 5 mm of distalization. Simulated deltoid muscle excursion was altered with increasing distalization, but amounted to no more than 0.8 mm change from baseline per 5 mm of distalization. Rotator cuff muscles consistently shortened less (or elongated more), up to 1.6 mm per 5 mm of distalization. These trends were observed across various patient motions.

DISCUSSION AND CONCLUSION: Isolated humeral distalization caused dramatic increases in the muscle forces required to perform scapular-plane abduction. Joint reaction forces increased correspondingly. These results suggest that implant and surgical strategies to generate deltoid muscle tension without humeral distalization may promote better active range of motion and more durable long-term outcomes over approaches that rely on distalization.